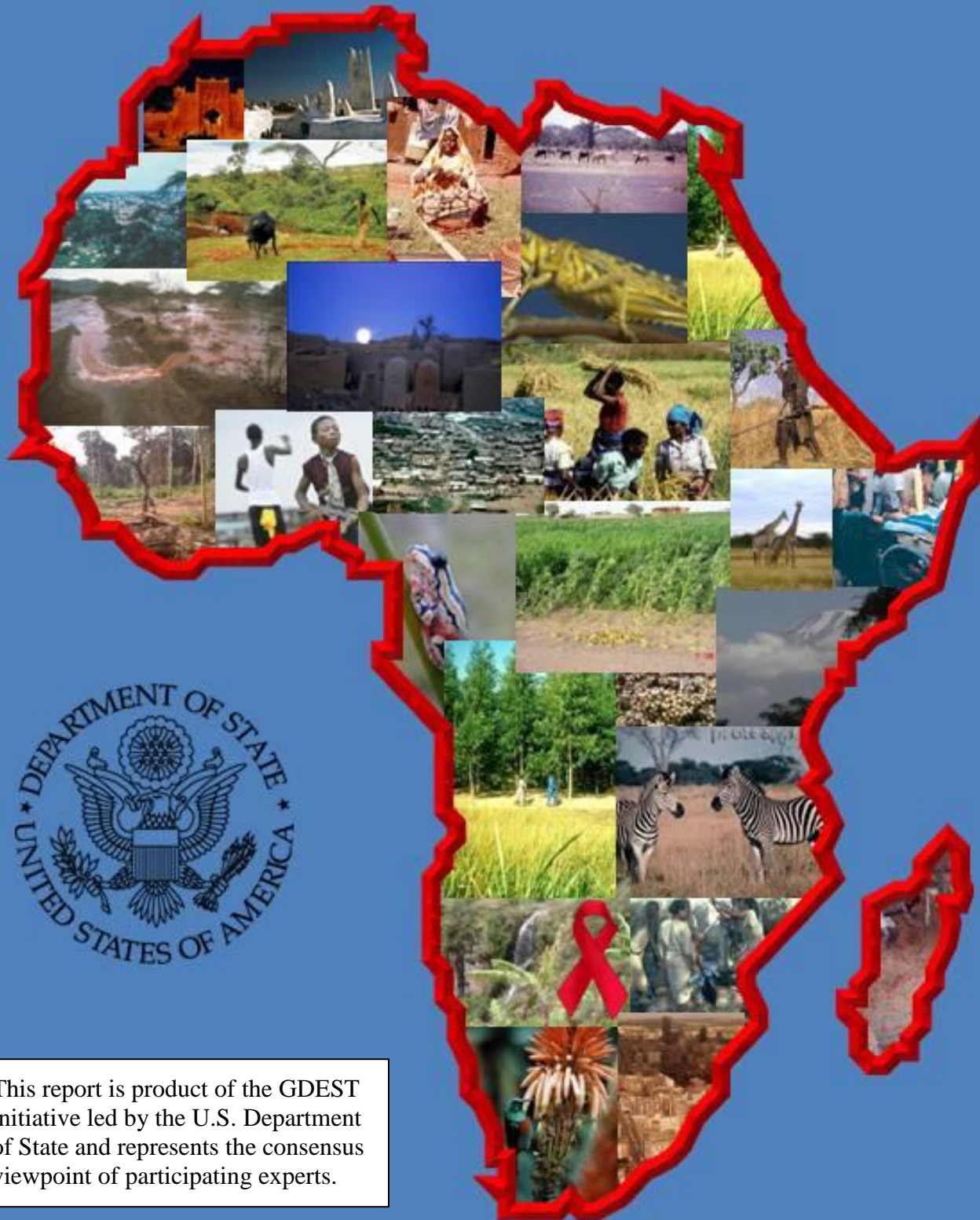


(Findings from GDEST site visits, March 2008)



This report is product of the GDEST initiative led by the U.S. Department of State and represents the consensus viewpoint of participating experts.

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Overview

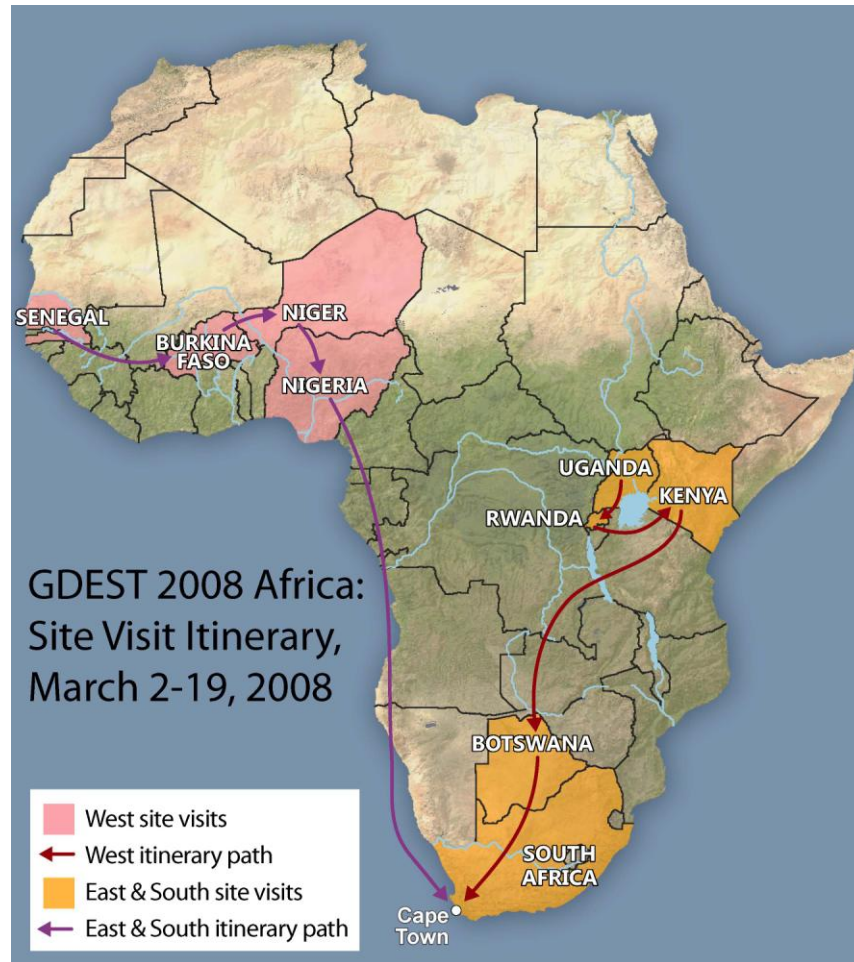
BACKGROUND

GDEST: Global Dialogues on Emerging Science and Technology

Since 2004, the U.S. Department of State, led by the Office of the Science and Technology Adviser to the Secretary of State, has conducted a series of bilateral and multilateral conferences to investigate trends in key science and technology (S&T) fields. These conferences, the Global Dialogues on Emerging Science and Technology (GDEST), examined these fields with counterparts in different regions of the world to address common objectives of global security, human aspects of sustainability, and opportunities for sharing knowledge and conducting joint research. Between 2004 and 2006, five GDEST conferences were held in Japan, Germany, China, India, and Brazil and dealt with, respectively: sensors and sensor systems, quantum information and coherence, genomics and infectious diseases, agricultural biotechnology, and bioinformatics. The conferences facilitated interactions among leading U.S. scientists and engineers and their foreign peers with special emphasis on involving young investigators.

On March 17-19, 2008, a sixth GDEST conference was held in Cape Town, South Africa, to address the topic of “Geospatial Sciences for Sustainable Development in Africa.” To establish a foundation for the regional conference, two U.S. teams of geospatial experts and policymakers visited nine countries in western, eastern, and southern Africa over a preceding two week period. Each team consisted of 7-8 members drawn from a variety of backgrounds, expertise, and institutional affiliations, including U.S. government agencies, non-governmental organizations, universities, and professional societies. “Team West” visited Senegal, Burkina Faso, Niger, and Nigeria. “Team East” traveled to Uganda, Kenya, Rwanda, Botswana, and South Africa. These countries were selected because they represented a spectrum of capabilities and contextual settings for geospatial science. Considerations such as the availability of field support to the teams and a variety of logistical factors were also important in determining the itinerary. Following two weeks of site visits, the capstone conference was held in Cape Town. The conference was attended by nearly 100 “geoscience” researchers and practitioners from 17 countries, many of whom had met with the U.S. teams during their country visits.

This report summarizes the team visits to the nine countries, including findings and observations about government and non-government organizations, research centers, and universities where geospatial sciences and related data, tools and policies are practiced, taught and applied. Proceedings of the GDEST conference are not provided here, but can be accessed at <http://2001-2009.state.gov/g/stas/events/c26700.htm>.



GDEST Visit Countries.

Geospatial Sciences for Sustainable Development in Africa

African countries face a wide range of challenges in their efforts to develop vibrant and sustainable economies that ensure the well-being of their populations. These include serious health, environmental, and governance obstacles that often reach critical levels. Geospatial sciences provide valuable tools to help develop insights on key issues, monitor trends, and analyze alternatives to achieve national and regional development goals. To effectively utilize these tools, African countries will need to develop their human resource capacities to establish a robust spatial data infrastructure, develop means to access relevant information, and strengthen networks among professionals so that decision makers receive timely and relevant information—and recognize the value of these information products in their everyday efforts.

Applications of geospatial science in African countries entered a new phase, beginning in the early 1980s, with the advent of the use of satellite imagery and

geographic information systems (GIS). However, the focus remained almost entirely project-based. These projects collected, analyzed, and distributed products that addressed specific issues for specific audiences. Such focused efforts enabled scientists and practitioners to broaden the impact of their projects, increase the analytical capability leading to project implementation, and demonstrate the value of geospatial analysis (particularly GIS and remote sensing modeling). However, because these projects were specific in focus and of a limited duration, much of the legacy data and knowledge from these efforts have been lost.

A major change in this project-specific approach occurred in the mid-1990s when the World Bank began a process of state-of-the-environment reporting, establishing national level environmental information systems (EIS) throughout sub-Saharan African countries. The World Bank reported in 1999 that over 500 EIS-related projects were underway.

Another major watershed occurred in the lead-up to the 2002 World Summit on Sustainable Development (WSSD). The U.S. Department of State, in collaboration with the U.S. Agency for International Development (USAID) and other USG and non-USG agencies, launched an initiative called Geospatial Information for Sustainable Development (GISD) in Africa. This initiative selected a variety of case projects throughout Africa that demonstrated the use of geospatial analysis at the applied level. GISD also funded a study carried out by the National Research Council, which resulted in a report titled *Down to Earth*¹.

At the same time, Global Earth Observation efforts have moved to establish regional data structures, analytical programs, and policy dialogues that have engaged national governments and institutions. The United Nations has facilitated these efforts by promoting data standards and availability, as well as supporting increases in institutional and human capacity at the technical level.

GDEST AFRICA THEMES

The 2008 GDEST Africa effort offered an excellent opportunity to contribute to initiatives already underway in African countries. Three GDEST Africa themes were addressed during the team visits, as well as the capstone Cape Town conference, to offer a framework for such a contribution:

1. **Observing Africa:** examining trends and opportunities for monitoring the environment and sustainability issues;
2. **Analysis of regional challenges to Africa:** how decisions and policies have been directly influenced by modeling, analysis, and visualization tools; and

¹ *Down to Earth: Geographic Information for Sustainable Development in Africa*, National Research Council of the National Academies, The National Academies Press, 2002.

3. ***The African data stream:*** constraints and approaches to obtaining valid data sets in a timely, affordable, and useful manner, and how best to share these among collaborators.

The region of sub-Saharan Africa offers an excellent frontier to further the growth in the application of geospatial sciences to address challenges of sustainable development. The charge to GDEST Africa collaborators was to effectively engage African scientists, engineers, and policymakers in this region to share common areas of endeavor and interest. This engagement involved exchanging expertise and resources with an awareness of the socio-cultural milieu, traditions, and institutions in which such collaboration takes place.

KEY GDEST TEAM OBSERVATIONS

Earth Observation

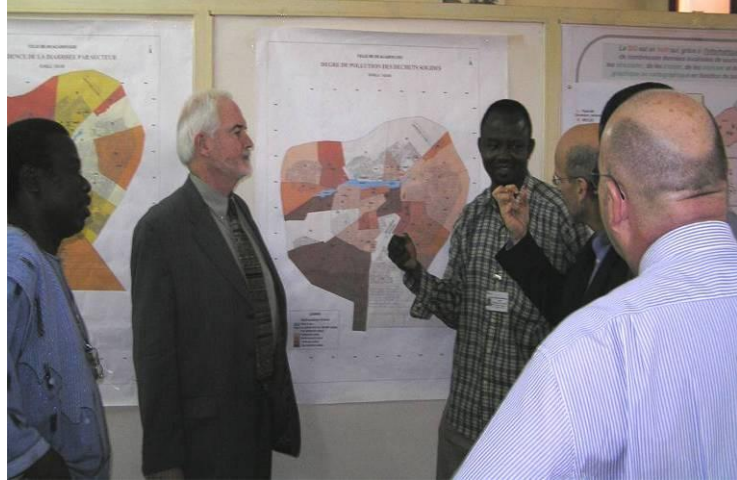
At the most fundamental level, earth observations provide strong visualizations of events and trends that are at the forefront of issues facing decision-makers in African countries. The strength of geospatial science and technology depends upon access to relevant data and imagery as well as capacity to analyze and present information that speaks directly to these decision-makers.

African countries have benefited from a lengthy history of collaboration with various agencies and organizations that have provided access to data and training in the use of these data for analysis. This collaboration has been primarily with European and U.S. entities, as well as various United Nations or other multilateral programs. The United States, through a donation by the National Aeronautics and Space Administration (NASA) in 2002, made historical Landsat imagery available to African scientists and practitioners via the UN Environment Program. The Global Earth Observation System of Systems (GEOSS) has also engaged a variety of African experts and institutions in its efforts to promote common technical standards, link users, and provide improved access to data and products. Although African scientists remain highly dependent upon foreign sources for satellite imagery and constrained by the cost of acquiring such imagery, recent efforts under the aegis of New Partnership for Africa's Development (NEPAD) and through the leadership of South Africa, Nigeria, Algeria, and Kenya are bringing the continent into the community of imagery producers. These countries jointly are part of the African Resource Management (ARM) constellation--a regional approach to imagery data that will help produce a critical mass of microsatellite engineering, sensing, reception, and product development on a continent-wide basis.

The analytical capacity for the use of satellite imagery within Africa is growing as a result of ongoing training. The Regional Centre for Training in Aerospace Surveys (RECTAS) is located at the Obafemi Awolowo University in Ile-Ife,

Nigeria and operates under the auspices of the UN Economic Commission for Africa (UNECA). It provides training and advisory services to UNECA member states. RECTAS is one of the key members of the University Network for Disaster Risk Reduction in Africa (UNEDRA). In spite of such growth in the capabilities of African institutions, however, no university on the continent offers a degree specifically in remote sensing and satellite imagery analysis.

Several key initiatives have been launched that offer an opportunity for greater African ownership and leadership in the process. The African Geodetic Reference Frame (AFREF), initiated under the auspices of UNECA, is conceived as a unified geodetic reference frame for Africa which will be the fundamental basis for the national and regional three-dimensional reference. When fully implemented, AFREF will consist of a



Dr. Jerome Dobson consults with members of L'Institut International d'Ingénierie de l'Eau et de l'Environnement (2iE) in Burkina Faso.

network of continuous permanent Global Positioning System (GPS) stations such that a user anywhere in Africa will have free access to GPS data and products and will be at most 1000 km from such stations. Another initiative, AfricaArray, is a partnership established to promote coupled training and research programs for building and maintaining a scientific workforce for Africa's natural resource sector. AfricaArray's initial focus on geophysics was designed to maintain and develop further geophysical training programs in African institutions; promote geophysical research in African countries with an Africa-to-Africa support system; and obtain geophysical data, through observational networks in participating countries.

Geospatial Research and Applications

The applications of geospatial science and research activities in African countries have grown in sophistication and breadth over the past decade. Four key drivers motivate these activities: urban development, conservation of biodiversity and natural resources, health, and crises such as famine and natural disasters. These issues have attracted donor funding and scientific inquiry, and represent challenges to the region as a whole. They also have engaged a range of institutions and organizations (government, multilaterals, non-governmental

organizations (NGOs), and universities) that set the stage for a wide network of collaborators over an equally wide range of disciplines.

A growing network of African geoscience practitioners has resulted in a significant community of interest that has driven a dialogue and process aimed at establishing geospatial infrastructures at national levels to support both research and applications. These networks consist of highly motivated and capable individuals at various levels within their respective organizations. However, the networks, and frequently the institutions themselves, tend to rely upon one dynamic leader for their existence and success. The institutionalization of geospatial science and the sustainability of the organizations that support research activities are slow in gaining mainstream budgetary support by their host governments.

The overall analytical capacity of geospatial scientists and practitioners is steadily growing throughout sub-Saharan African countries. Currently, geospatial products are more commonly thematic rather than prospective. Researchers and practitioners have emphasized the need for developing analytical capacity that makes a broader use of modeling in order to lay out scenarios, present trends, and outline potential outcomes of development efforts. During the GDEST site visits, many of the scientists who met with the GDEST teams expressed frustration that their products are not being more widely used by their government's decision-makers. Conversely, the scientists themselves may require a broader understanding of the needs of decision-makers as clients of their products. By more directly orienting applications of geospatial science to the formats, timeframes, and content needed by decision-makers, scientists and practitioners in African countries may be able to better meet the needs of their clients and generate increased demand – and associated funding – for these efforts.



Dr. Fernando Echavarria and Dr. Melba Crawford have a discussion with Université Abdou Moumouni faculty in Niger.

Data Gaps, Requirements, and Coordination

Numerous networks in sub-Saharan Africa exist that are helping to close gaps in information, define requirements, and coordinate data access and exchange among professionals. These range from academic/scientific communities, NGOs

and university networks, to networks and organizations associated with regional inter-governmental organizations.

Standards and geospatial infrastructure are slowly being developed at a regional level through such programs as UNECA's Committee on Development Information, Science and Technology (CODIST), as well as by national initiatives, particularly in Rwanda, South Africa, and Botswana. Informal efforts are also being undertaken by NGOs and at project levels. Tensions sometime exist between these efforts when less formal approaches often provide dynamism but offer slow aggregation to achieve a critical mass in adoption, while regional and national efforts engage in lengthy dialogue, but achieve high level legitimacy once consensus is achieved. These two approaches are not mutually exclusive, yet they require attention to ensure that conflicting methods and standards do not emerge from their parallel evolution.



GDEST team members meet with the staff of the Harry Oppenheimer Okavango Research Center in Botswana

Geospatial Science and Technology Collaboration

The environment is rich for opportunities to collaborate on the strengthening and application of geospatial science and technologies in sub-Saharan African countries, among African institutions as with the U.S. as well. One initial opportunity is to support the development of data guidelines for donor projects in order to ensure that data are collected and stored in compatible formats, that protocols exist for access to these data and their long-term archival, and that technologies are in place to ensure that these processes continue.

There is extensive interest in collaboration among universities using shared curricula, student and faculty exchanges, and joint research efforts. One guiding principle to facilitate sustainability of these efforts is that collaborating parties need to generate their own funding rather than rely on outside donors and the budgetary vagaries that might entail.

African scientists commonly expressed their need for access to commercial imagery and high resolution data at affordable prices. The GDEST Africa effort can help to engage providers of remotely sensed data and high resolution elevation data in order to achieve some concessionary pricing structure and to engage national imagery agencies to provide national imagery through appropriate means.

Strategic partnerships can be established to support and enhance regional data centers and organizations, such as EIS-Africa and the Regional Center for Mapping of Resources for Development (RCMRD). This includes support to ensure their financial and programmatic sustainability as well as offering opportunities for their direct engagement in activities of mutual interest. The American Association of Geographers (AAG) and the American Geographical Society (AGS), as well as the American Society of Photogrammetry and Remote Sensing, the Institute for Electrical and Electronics Engineers, and other professional societies are favorably positioned to support these efforts.

The Department of State could potentially play a role in supporting a range of applications of geospatial science and technology through such programs as Fulbright Fellowships and the U.S. Department of State Embassy Science Fellows. This would require a concentrated focus to identify host institutions, areas of interest, and available scientists who could spend sufficient periods of time in country to ensure a measurable result.

Increasingly, the African university community offers a means for sustaining analytical efforts beyond the limited time frames of project funding. Universities can be “islands of stability” for cooperation because they educate the next generation of scientists, engineers, and public policy leaders. Governments could consider their universities critical national assets and engines for economic development, with the potential for accessing global networks. This would provide an incentive for governments to continue investing in their universities, including their research infrastructures and activities, even in difficult times. When university faculty, particularly those with tenure, do not entirely depend upon project funding to meet their salary needs, they can maintain activities at a certain level once funding ends or until further funding can be obtained.

The African Union is establishing a network of universities to foster further regional collaboration. This network may offer another opportunity for geospatial sciences to strengthen collaboration among universities, set academic standards for degree and certificate programs, and harmonize curricula, without the necessity of relying on foreign partners.

SUMMARY FINDINGS

In summary, ***several key findings*** emerged from the GDEST team visits to the nine sub-Saharan African countries:

1. Geospatial science and technology and GIS capabilities exist within African countries that can and should be enhanced;

2. There was a strong consensus that capacity-building should focus on existing efforts rather than create new initiatives or institutional arrangements;
3. African scientists and practitioners expressed great enthusiasm for collaboration, particularly working with U.S. partners;
4. Many African counterparts and the site visit team members noted that the U.S. presence in many sub-Saharan African countries has been decreasing for many years;
5. Collaboration is most effective when it is consensus-based and engages African partners at all stages, from conceptualization to implementation of activities.

As the GDEST Africa effort progresses, a **set of principles** can act as a guide for future collaboration:

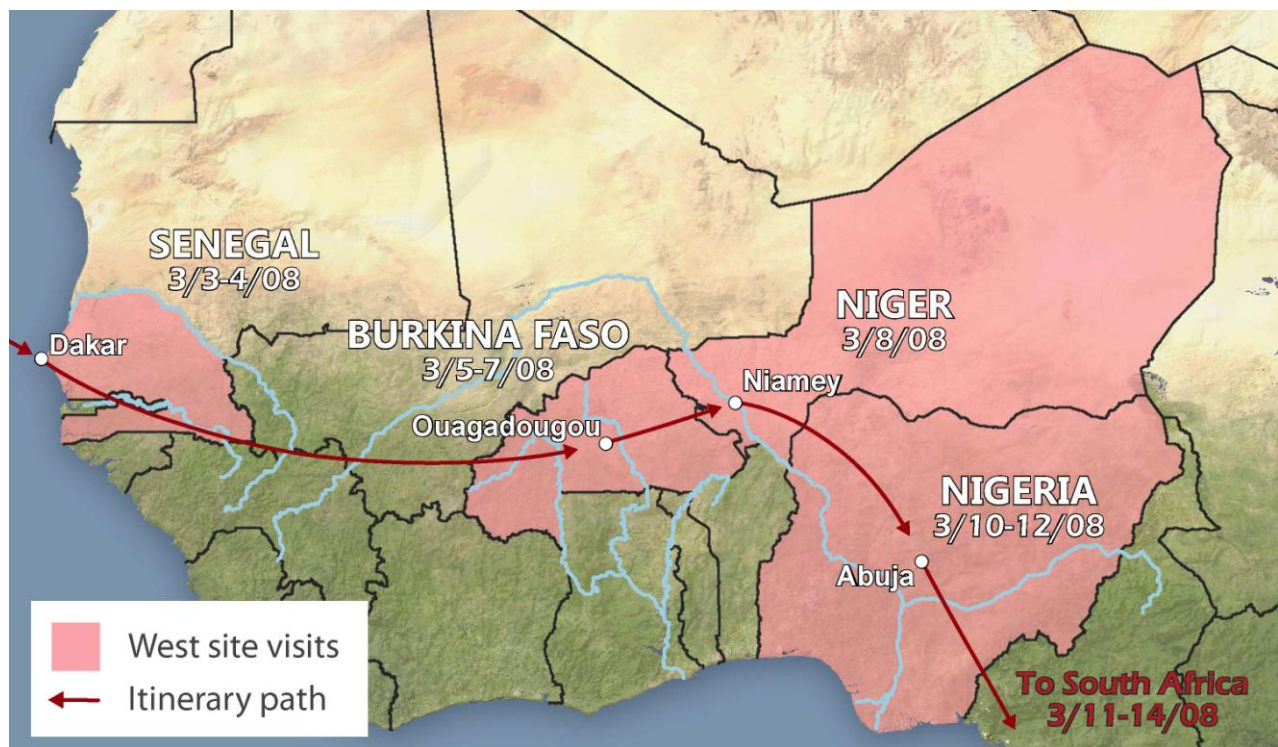
- ❖ Follow-on collaboration should avoid diluting the accomplishments of ongoing activities by **linking to and reinforcing existing capacity and networks** rather than importing new and foreign institutions,
- ❖ **Regional expertise** should be brought to bear as much as possible, including for training and education efforts, to foster collaborative efforts.
- ❖ Collaboration efforts should from the outset **engage African experts** as equal partners in the conceptualization, design, and implementation of any shared geospatial science project or program.
- ❖ **Promoting university-to-university relationships** can help provide “islands of stability” through shared curricula, faculty and student exchanges, and joint research that can continue after specific project funding ceases.
- ❖ Collaboration should **make use of an already existing events calendar** to maximize the effectiveness of their information sharing efforts. In particular, recurring meetings such as the African Association for Remote Sensing of the Environment (AARSE) conference, the International Geoscience and Remote Sensing Symposium (IGARSS), and the AfricaGIS conference offer excellent opportunities to link to a large constituency in place and thereby increase overall resources devoted to both national regional efforts, including participation by a greater number of stakeholders.
- ❖ Managers of ongoing U.S./African GDEST activities should establish milestones to **track the progress of collaboration efforts** they are making and adjust objectives, resources, and timetables to ensure maximum benefits to all stakeholders.

PROGRESS SINCE 2008

In the year since the GDEST Africa team visits and capstone conference in March of 2008, some notable progress has been made under the GDEST “banner” in both establishing new and strengthening existing collaboration efforts among geoscience specialists working on sustainable development issues in Africa.

- The U.S. government, through a grant administered by the State Department’s Bureau of Oceans and International Environmental Scientific Affairs (OES), has provided funding to support a partnership between the Association of American Geographers (AAG) and EIS-Africa, an NGO based in South Africa. In one of its first pilot projects, EIS-Africa is collaborating with researchers in Burkina Faso, Uganda, and Namibia to link baseline data sets to high resolution imagery for the analysis of key sustainable development issues. This grant has also enabled the two organizations to establish a strategic partnership to support facilitation of regional networking, information sharing, and collaboration between and among African and U.S. counterparts working in the geospatial sciences. Part of this partnership includes joint membership opportunities in the AAG and EIS-Africa.
- A network of scientists from the “African Diaspora” has been established in the United States in order to return the expertise for analyzing key issues to their countries of origin.
- The U.S. Department of State and other USG organizations have begun a process to investigate and respond to African country needs for higher resolution imagery and other geospatial resources that can be shared on an as-needed, emergency, or regular basis.
- African country requests for the temporary assignment to their countries of U.S. geospatial experts are being addressed through a variety of possible vehicles, including the State Department’s Embassy Science Fellows program and Fulbright scholarships.
- U.S. government agencies, primarily the United States Geological Survey (USGS), have been providing ongoing support to UNEP’s GRID-Sioux Falls program, a major partner in the production of UNEP’s *Africa: Atlas of Our Changing Environment* and a similar Atlas of Kenya. In addition to Landsat imagery, U.S. government agencies also provided higher-resolution imagery for use in production of the atlases.

Team West Country Visits: Overview



SENEGAL

Senegal has historically served as a gateway to West Africa. It is equipped with a modern infrastructure and has one of the most stable governments in Africa, which it has enjoyed since independence in 1960. The country maintains strong ties with France, a legacy of the colonial period, and warm relations with the United States. While nearly 70 percent of its people are farmers, the urban proportion of Senegal's population of approximately 13.7 million is steadily increasing (the overall rate of natural increase has remained high, at around 3 percent). While its economy is primarily based on agriculture, particularly the production of peanuts and cotton, this sector has recently fallen on hard times.

Senegal still faces serious challenges in its economic, agricultural and environmental sectors. A rapidly growing population is placing increasing stress on Senegal's limited land resources, agricultural production, and forest resources. There is a tremendous need for more advanced geospatial data and information that goes beyond mapping and monitoring, to modeling future scenarios, engaging decision-makers, and responding to the rapidly changing economic and environmental landscape.



Dakar, Senegal.

Earth Observation

Senegal relies heavily on European and American satellite systems for their earth observation needs. It has a relatively long history of using satellite remote sensing, including USG Landsat imagery, to systematically monitor environmental conditions on a near real-time basis. Prime examples include range and biomass monitoring for livestock production and bush fire monitoring and mapping. There is some capability to download imagery data directly from Meteosat and National Oceanic and Atmospheric Administration (NOAA) satellites. Other data must be retrieved through the Internet or through cooperative projects with European or North American partners.

Geospatial Research and Applications

Principal ongoing research topics include remote sensing applications on: bush fires, carbon sequestration, agriculture, climate change, erosion, flooding impacts on settlements, biodiversity, and mangrove ecology. Work has also been done on long-term land use and land cover change, monitoring the evolution of urban sprawl, and real-time modeling of sea surface temperature to produce indicators of fish concentration. Centre de Suivi Écologique (CSE, the Center for Ecological Monitoring under the Ministry of Environment) is collaborating with the UN Food and Agriculture Organization

(FAO) on a project to assess land degradation using innovative remote sensing techniques.

Data Gaps, Requirements, and Coordination

Implementing Senegal's National Geomatics Plan (NGP), much like the U.S. Geospatial Data Infrastructure model, will serve as a blueprint for promoting universal data standards, data infrastructure, and data harmonization. The Canadian government is presently helping support the implementation of Senegal's NGP. Still, researchers throughout Senegal require increased access to some key medium and high resolution data, including 30-meter Shuttle Radar Topography Mission (SRTM) imagery for digital elevation modeling.

Geospatial Science and Technology (GST) Collaboration

Senegalese scientists often request free or low-cost imagery to support their research. Current GST collaboration efforts with American institutions are limited, though Senegalese universities have a history of collaboration with the United States in GST, starting with Cheikh Anta Diop University and South Dakota State University in 1979. CSE, in particular, has a number of joint collaborative projects, including a forest management project with USAID and a long-term land use mapping and monitoring project with the United States Geological Survey (USGS). There are many more collaboration projects between CSE and European university partners, particularly the Danish.

Summary Findings

Senegal offers strong possibilities for increased international cooperation in the geospatial arena owing to the numerous opportunities to collaborate with private, university, and government institutions. The GDEST team found a wealth of ideas and considerable willingness for collaboration in a number of thematic areas of considerable importance to Senegal. All of these are themes of interest to American geographers and agricultural and environmental scientists, many of whom are facing similar problems in the United States.

One reason that Senegal is poised to make progress in the use of geosciences for decision-making is that its government has drafted a National Geomatics Plan (NGP). This plan should make it easier for U.S. partners to understand the priorities in Senegal for geospatial data, data formats, and even applications. It also has the potential to help U.S. researchers better determine how and which activities to link to and support in Senegal, especially if these activities are tied to national development and research priorities. The NGP can serve as a legal document to help potential collaborators in the United States build partnerships and joint projects in Senegal. Many Senegalese geographers, for example, called for the need for high-resolution imagery and the desire to work with U.S. research partners on a project basis using such imagery. Colleagues at Direction des Travaux Géographiques et Cartographiques (DTGC) mentioned a desire to participate and contribute to regional and global processes for Spatial Data Infrastructure (SDI) development via structures such as the Committee on Development

Information's Subcommittee on Geo-information (CODI-Geo). Other possibilities for collaboration included working, at the regional level, with Nigeria's Regional Centre for Training in Aerospace Surveys (RECTAS) and, at the global level, with the Integrated Global Observing Strategy (IGOS), Committee on Earth Observation Satellites (CEOS), and Group on Earth Observations (GEO).

The Agence de l'Informatique de l'État (ADIE), directly under the office of the President, functions as a coordinator and policy body for defining Senegal's strategy to modernize its use of information technology (IT) as well as develop its communications infrastructure. The goal is to collect information for multiple sectors including industry, enterprises, individuals, and NGOs on natural resources, land tenure, enterprises, environment and environmental trends, and population.

Senegal could serve as a regional power broker in the field of geomatics and geospatial information. Such a role could go well beyond making maps for the purpose of map-making, but to satisfy mandates, answer specific questions, and shed light on challenges faced by the country as well as those shared throughout the region. This would ultimately allow Senegal to better serve the needs of its people in geospatial information and enable the government to better provide for multiple needs of its population, including traditional infrastructure, transportation, basic services, health, environmental management, and disaster preparedness and mitigation.

Two institutions that the team felt merited particular consideration for the development of future collaborative projects were the Laboratoire d'Enseignement et de Recherche en Géomatique (LERG) at the University of Cheikh Anta Diop (UCAD), and CSE. Both are involved in research and applications that have great potential to help Senegal address serious social, economic, and environment problems. Both are very willing



Team West with Senegalese geospatial experts at a roundtable discussion.

partners and CSE in particular has a history of working with American scientists (since 1993) in geospatial sciences. Furthermore, CSE, as a technical arm of the Ministry of Environment and a regular advisor to both the President and Prime Minister on environmental matters, has great potential to influence decision-making in Senegal. One of CSE's mandates is to produce a 'state of the environment' report every two years, including recommendations to policy-makers on major environmental policy initiatives and actions that may mitigate environmental problems. This represents an excellent opportunity for specific project partnerships that help CSE gather and analyze data for this report. CSE has worked successfully with U.S. partners on similar initiatives in the past, particularly with the USGS Earth Resources Observation Systems (EROS) Data Center (USGS/EDC).

LERG is an ideal partner for pairing with American universities conducting similar environmental research. The breadth of environmental research topics in which this

research center is engaging is impressive, and its limited resources would be bolstered considerably by capacity-building partnerships.

During the GDEST team visit to Senegal, the U.S. Embassy facilitated a roundtable discussion with a group of local geospatial experts from various organizations. One of the most significant outcomes of the discussion was the suggestion by Mr. Aliou Dia, a GIS officer at the United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA), to create a small working group of Senegalese geospatial stakeholders to be the focal point for continuing the dialogue with the GDEST delegation.

This working group is to help define concrete projects that are both useful and constructive in addressing a particular development problem in Senegal – an activity that could allow the United States to provide expertise or remote sensing data that would be applied to this specific application. Continued dialogue with the geospatial working group will be instrumental in defining any project development needs and identifying potential Senegalese and US partnerships.

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Laboratoire de Télédétection Appliquée (LTA), Institut des Sciences de la Terre, Université Cheikh Anta Diop (UCAD), Senegal	52
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BURKINA FASO

Burkina Faso is a landlocked country that bridges West Africa's semi-arid Sahelian and sub-humid Sudanese climatic regions. Burkina Faso has few natural resources; agriculture represents a third of its gross domestic product (GDP), while about 80 percent of its people are engaged in agriculture. As elsewhere in the region, the urban sector is increasing in size, with strong rural to urban migration. In the north, most people are pastoralists. Agriculture dominates the central plateau and has expanded significantly in the past few decades into the southeast and southwest parts of the country. Cotton is the main cash crop, and livestock production is also an important source of revenue.

Burkina Faso faces major challenges in sustainably balancing its scarce natural resource base with feeding a population of about 15.7 million that is growing rapidly at 3 percent a year. At \$1300 USD, its GDP per capita income is one of the lowest in the world. There is a strong need for geospatial data and information to help map, monitor, and plan for more sustainable use of its land resources. Applications of geospatial technologies are needed in the water, environment, agriculture, and urban planning sectors in order to meet the economic challenges faced by its citizens.



The village of Rissiam, several hours from Ouagadougou.

Earth Observation

Institutions in Burkina Faso have a relatively long history in using satellite remote sensing for applications in land management. In the mid-1970s, the United States, several European partners, and the Government of (then) Upper Volta created the Regional Remote Sensing Center in Ouagadougou (CRTO), with a goal of downloading and archiving imagery data from NASA's new Landsat program. Thousands of images were archived at this center, which also provided training within the region in remote sensing applications. The center closed in the 1980s due to the loss of support from funding institutions. It succeeded, however, in creating awareness and interest in applying geospatial tools in Burkina Faso and in the region.

The institutions the team visited indirectly receive transmissions of satellite imagery through strong partnerships both within the region (e.g. with the Agricultural, Hydrological, Meteorological Regional Center – AGRHYMET – in Niger) and with European and North American governments and partners. Many scientists in Burkina Faso are able to access a variety of recent sources of remotely sensed imagery.

Conventional remote sensing using aerial photography is quite strong, with institutions like the Institut Géographique du Burkina Faso (IGB) conducting aerial surveys as needed. Availability of historical and current aerial photography is good. International research institutions like former French ORSTOM (renamed the Institut de Recherche pour le Développement (IRD)) have made considerable use of aerial photography to map the natural resources of Burkina Faso. Detailed national baselines exist on geology, hydrology, soils, vegetation, and land use.



Dr. Fernando Echavarria, Tim Mroz, and Dr. Melba Crawford visiting the Institut Géographique du Burkina Faso.

The integration of geospatial tools and earth observation continues to increase among various private and public institutions in Burkina Faso. The Centre de Système d'Information Géographique et Télédétection (Centre SIGET – Adjaratou), is aggressively applying GIS and remote sensing to a variety of land management and monitoring applications. This center periodically updates its holdings through strong partnerships with the USGS EROS, and maintains strong ties to African and United Nations networks in geospatial technologies. Government institutions like the Institute on Environment and Agricultural Research (INERA), and the National Council for Environment and Sustainable Development (CONEDD) rely on a partnership with the AGRHYMET Regional Center for regular access to derivative products from satellite imagery, particularly for monitoring land use change and agricultural production.

Geospatial Research and Applications

The use of geospatial technologies in Burkina Faso ranges from conventional applications of aerial photography for cadastral and topographic mapping to state-of-the-art applications of satellite remote sensing and GIS for pressing issues in the thematic areas of environmental monitoring and analysis, disaster management, health care, education, agriculture, energy, and climate change. The scope and scale of most projects using geospatial tools are modest, and the number of skilled staff limited. There seems to be considerable interest among upper level students, government staff, and senior government officials in furthering the use and application of geospatial tools in Burkina Faso. There is a pressing need for training in mapping and analysis services in cartography, image processing, and GIS. Among the most progressive and energized institutions the team visited were the SIGET Center – Adjaratou and the International Institute for Water and Environmental Engineering (2iE). Most uses of geospatial technologies in these two centers are focused on local to national scale applications, rather than research. The 2iE institute members are interested in using geospatial tools for global change research, particularly the implications of climate change for Burkina Faso.

Data Gaps, Requirements, and Coordination

Institutions in Burkina Faso lack the capability of directly downloading satellite data, a key component of real-time environmental monitoring. Instead, satellite image data are acquired on an ad hoc basis, usually driven by specific project needs. The United States or other international partners could play a more direct role in strengthening the access to current imagery either by helping practitioners acquire imagery through low-cost satellite receivers, or by increasing the Internet bandwidth for downloading large image datasets. This could include supporting efforts for a trunk line (i.e. Internet 2.0).

In the GIS area, institutions enthusiastically use U.S. geospatial technologies. What is lacking in Burkina Faso is both experience in GIS applications in support of pressing social problems, environmental and agricultural needs, as well as resources for training, software licenses, and ready access to current satellite imagery. The United States is in a good position to provide no-cost data. USGS, for example, has opened its entire Landsat archive to the world, providing all scenes free-of-charge. The USGS capability could be leveraged to seek research and applications partnerships that capitalize on this mostly untapped resource. Applications that involve studying a changing environment with time-series imagery are particularly needed and germane to the challenges of climate and environmental change and research.



Team West visiting the SIGET Center – Adjaratou.

Geospatial Science and Technology (GST) Collaboration

The current level of collaboration between the United States and Burkina Faso institutions is limited—more due to a lack of resources than to a lack of interest in scientific collaboration. Historically, the United States has had a much greater presence in the economic development and scientific arenas with Burkina Faso than it does today. Opportunities for collaboration in geospatial technologies became more limited when USAID closed its mission to Burkina Faso in the mid-1990s. Despite this, much goodwill remains between the two nations, and the United States has an opportunity to strengthen its bilateral partnerships through scientific applications and research.

The Famine Early Warning System Network (FEWS NET) Project is a well-established USAID project active in Burkina Faso. FEWS NET is designed to monitor food security in the region and assist with U.S. decision-making with regard to response to food and humanitarian crises. Since 1987, FEWS NET has maintained partnerships with Burkina Faso and regional West African institutions, promoting the sharing and exchange of geospatial information on such themes as crop condition, rainfall, agricultural production, market data, and health and nutrition.

In recent years, the USAID/West Africa Regional Program has promoted regional and U.S. collaboration with Burkina Faso institutions: USGS/EDC, AGRHYMET's Regional Program, INERA, and CONEDD. The project uses time-series Landsat and Corona satellite imagery to study, map and monitor the changing land use and land cover patterns across the country, from the 1960s to the present. The USGS has provided imagery and training workshops to staff from these institutions in support of the project goals.

Summary Findings

Burkina Faso is in the heart of the Sahel region, a transitional bioclimatic region between the Sahara Desert and the sub-humid tropics. Global climate models predict that this region will undergo significant change in the 21st century, shifting towards warmer temperatures and lower rainfall. Burkina Faso is an ideal place for collaborative research on the impacts of global warming. The country faces huge challenges of a growing population on a limited physical resource base. Geospatial technologies can play a major role in helping decision-makers plan for a more secure future.

The Burkina Faso government places a priority on the education and modernization of the country. Support for the application and research of geospatial technologies in the country's economic development, and for environmental concerns, is encouraged at the highest levels. While there is considerable interest in developing and applying geospatial technologies, the cadre of experienced users of GIS and remote sensing is quite small. University of Ouagadougou provides training, as does SIGET, a private remote sensing and GIS center. At both institutions, limited hardware and software availabilities constrain training. Collaborative projects with international scientists that result in building hands-on remote sensing and GIS capacity in government and private institutions is needed. Training partnerships between the University of Ouagadougou and U.S. academic institutions in geospatial technologies would be welcome.

The growing demand of Burkina Faso's urban population for water is a major concern. The government is building a network of dams and dikes to retain water and could make better use of geospatial science technologies for hydrological applications.

In the new era of low-cost or no-cost satellite imagery at coarse to fine spatial resolutions, the country would benefit from investments in expertise. The United States has an opportunity to make a difference by providing expertise in fields that rely on remotely sensed imagery. Burkina Faso faces huge challenges in natural resource management, given its limited natural resource base and burgeoning population growth. The Government of Burkina Faso is especially open to forming international partnerships and encouraging foreign investment.

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NIGER

Niger covers an immense area in central West Africa. Occupying a huge plateau, the country is diversified based on its underlying geology. It is also climatically diverse, with two distinct ecological regions: the Saharan Region which receives almost no rainfall, and the Sahel region – a semi-arid belt that runs the length of southern Niger where agriculture is concentrated. The Niger River provides water for irrigated rice; off-season vegetable farming using surface or near-surface water is growing.

Niger's population of 14.7 million is one of the fastest-growing in the world, with an annual rate of 3.1 percent. About two-thirds of Niger's population of 14.7 million is less than 25 years of age, and only 17 percent live in urban areas. Over 80 percent of Niger's population is engaged in sedentary agriculture.

The transition zone between the Sahara and Sahel supports widely scattered nomadic pastoralists. Livestock, sold to neighboring countries, constitutes a major component of Nigerien economy and household security, both among pastoralists and settled farmers.

Uranium mining also contributes significantly to the Niger economy, but earnings from this mineral shrunk considerably as the world market has declined. U.S. companies have taken interest in gold, coal, and petroleum in recent years.



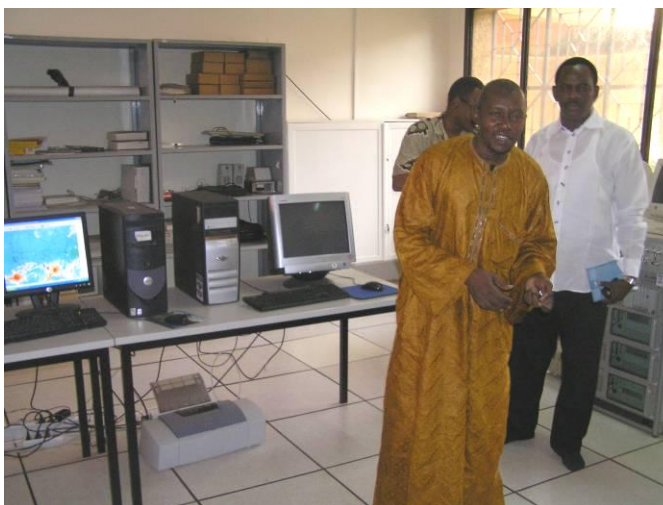
Niger River running through the capital city of Niamey.

Environmental degradation and the desertification threat dominate strategic planning in the development community. A recent study used time-series remote sensing and field data to show evidence of significant environmental improvement in two ecological regions of south-central Niger. One significant finding is the major increase in tree cover on farmlands in areas of high rural population density. Farmers are investing in the land using a variety of natural resource management techniques, including the enhancement of natural tree regeneration. These findings suggest a human and environmental success story at a scale not seen before in the West African Sahel. Niger's policy environment is changing, in particular a rural development code reform that mandates a decentralized approach that empowers local people to manage their own resources.

Earth Observation

The GDEST team visited three institutions in Niger, all of which to varying degrees use remote sensing for mapping and monitoring land resources. Of the three, one institute

stands out in terms of its use of geospatial technologies: the Agricultural, Hydrological, Meteorological (AGRHYMET) Regional Center. AGRHYMET's primary objectives are to contribute to achieving food security and increased agricultural production in the Sahel, and to improve natural resource management by providing training and information to development stakeholders and partners. AGRHYMET acts as a regional center of excellence in the applications and research of remote sensing and GIS in West Africa. Powerful computing



Laboratory at the AGRHYMET Regional Center, Niamey, Niger.

capability and a receiving station for NOAA-AVHRR (National Oceanic and Atmospheric Administration-Advanced Very High Resolution Radiometer) and Meteosat data support the AGRHYMET researchers. In this capacity, Niger is unique in the Sahel region. Since 1989, AGRHYMET has monitored weather, rainfall, and vegetation conditions across the Sahel. AGRHYMET has similarly used Landsat, ASTER, SPOT (Satellite Pour l'Observation de la Terre), and other medium resolution imagery to map and monitor land use and land cover patterns. It has archived medium resolution imagery with assistance from the USGS EROS Center, and the European Space Agency. AGRHYMET hopes to continue its U.S. partnerships and expand its ability to receive and use satellite data, particularly MODIS (Moderate Resolution Imaging Spectroradiometer) on the NASA Terra and Aqua platforms.

The Institut Géographique National (IGN) uses aerial photography for updating its topographic map series but does not regularly use imagery for earth observation. Centre Régional d'Enseignement Spécialisé en Agriculture (CRESA), a relative newcomer to geospatial technologies, is beginning to use imagery in recent projects.

Geospatial Research and Applications

AGRHYMET is the leading institution conducting geospatial research and applications in Niger (though technically it is a regional entity rather than a national one). It has had experience in remote sensing and GIS since its inception in 1974. AGRHYMET is engaged in an ambitious range of applications and research, all of which use geospatial tools. As a regional entity, it serves the nine member countries in the Sahel region, and supports some of the coastal countries outside the Sahel region as well. It works closely with European and North American partners, and has a long and productive history of collaboration with U.S. institutions, particularly, NOAA, NASA, and the USGS, with support from USAID.

The University of Abdou Moumouni's CRESA Center presents a considerable opportunity to conduct agricultural research. CRESA's ambitious staff is engaged in natural resource management, soil science, and agroforestry, and recently integrated

remote sensing and GIS into some of their projects. They have a keen interest in expanding the use and experience in geospatial tools, and in providing better training to university students. CRESA would like to build on recent U.S. partnerships.

Data Gaps, Requirements, and Coordination

AGRHYMET relies solely upon NOAA and Meteosat imagery and is seeking ways of expanding its archive of medium and high resolution imagery. It could do so through agreements with U.S. institutions, but internet bandwidth issues have severely limited its ability to download major datasets. Increasingly, AGRHYMET and its member country institutions see the need for medium and high resolution, well-calibrated image data, particularly in support of agriculture and natural resource management applications. Their current holdings of recent medium and high resolution imagery are limited, and most of their Landsat imagery is over eight years old. They have very little high resolution imagery. The United States could significantly help in these areas, ideally through specific applications projects that call for current medium and high resolution imagery.

CRESA is starting to acquire basic hardware, software and imagery to support training and applications. CRESA is conducting exciting new research on improved environmental management by farmers coping with declining rainfall. CRESA is also interested in quantifying carbon sequestration under various agricultural management practices. These themes represent areas of potential scientific collaboration with U.S. partners.

As elsewhere, the United States is in a good position to provide no-cost or low-cost image data to support specific projects. Applications that involve studying a changing environment with time-series imagery are particularly needed and germane to the challenges of climate and environmental change.

Geospatial Science and Technology (GST) Collaboration

Current collaboration between the United States and Niger in geospatial science is ongoing, mainly through a joint project between USGS EROS and AGRHYMET. Under this project, the USGS has also collaborated with the IGN, a national counterpart in mapping the land cover of Niger. CRESA and the USGS are also completing a cooperative research project on farming practices in south central Niger involving time-series imagery to evaluate environmental change.

Niger's pressing needs to increase food production to feed a growing population and to prepare for decreasing rainfall point to potential research in monitoring and modeling rainfall level trends and alternatives in order to assess human vulnerability and coping mechanisms. Niger has reformed environmental and forestry codes and devolved considerable authority to local communities. Studying the impacts of these efforts on food production, soil fertility, increased biomass and carbon, and even local rainfall patterns present a major opportunity for collaborative research.

AGRHYMET has an impressive record of projects that have made a difference to tracking agricultural and rangeland conditions – and food security – in the region.

AGRHYMET's relationships with U.S. and European partners already bolster its efforts; international donors could look for more opportunities to raise the visibility of this work, and to build upon it to better serve the governments in the region.

Summary Findings

The use of geospatial technologies in Niger at the country level has been modest. However, the AGRHYMET Regional Center's long history of applications, research, and collaboration with the U.S. Government is quite impressive. As in Burkina Faso, the closure of the USAID mission to Niger in 1996 has curtailed many opportunities for working at a bilateral level with Nigerien institutions (but did not directly affect collaboration with AGRHYMET).

Niger faces huge challenges given its rapid population growth, limited rainfall in the narrow agricultural strip along its southern border, and a relatively poor resource base. U.S. scientists, engineers, and research institutes have an opportunity to make a difference in Niger through specific collaborative projects that address the sustainability of agricultural production, natural resource management, and modeling of future ways to cope with climate change.

In the past 20 years, farmers have changed their management of soils and on-farm vegetation, resulting in an impressive positive transformation of agricultural landscapes. If the Niger experience were studied and analyzed, it could potentially be applied to other Sahelian countries. Working with CRESA and the AGRHYMET Regional Center would provide excellent platforms for applying geospatial technologies to these sustainability challenges.

U.S. Government institutions have been collaborating with AGRHYMET since it opened in 1974. There is considerable momentum and synergy which could be built upon, beginning with the definition of specific projects that continue to help AGRHYMET serve the region's critical needs.

Institutions Visited

Centre Régional de Formation et d'Application en Agro météorologie, Hydrologie et Météorologie (AGRHYMET), Niger	67
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Institut Géographique National (IGN), Ministry of Urban Planning, Habitat, and Cadastral Mapping, Niger	71

NIGERIA

The Federal Republic of Nigeria is Africa's most populous nation, with nearly 150 million inhabitants. With its population currently growing at a rate of approximately 2.5 percent a year, some estimate that by 2050 one of three Africans will be Nigerian. Fueled by its oil and gas resources, Nigeria is the regional economic and political powerhouse of West Africa. High oil prices boosted Nigeria's GDP beyond that of South Africa and in 2008, its \$328 billion GDP grew at a rate of 6.2 percent. Per capita GDP is still relatively low, however, and 70 percent of Nigeria's workforce remains primarily employed in agriculture.

Nigeria's vast territory includes a diverse agglomeration of ethnic groups (over 250) from different religious, linguistic, and cultural traditions. This diversity gives rise to major religious and political rifts within the country, which in the past have brought violence and political instability. Northern Nigeria sits at the edge of the Sahel, and most of the population in the northern part of the country is Muslim, primarily farmers and traders and semi-nomadic herders. Southern Nigeria sits along the populous subtropical West African Coast, with a predominantly Christian population.

Nigeria has an educated managerial and technological elite, much of it schooled in Europe and North America. However, this elite group is still relatively small. The government is committed to raising the scientific and technological capacity of its population through heavy investments in education, research, and development infrastructure. Due to its large territory and population, as well as its vast hydrocarbon resources, Nigeria is a special case within the West African region, offering some of the greatest opportunities for collaboration with international partners in the applications of geospatial technologies.



The National Space Research and Development Agency (NASRDA) in Abuja, Nigeria.

Earth Observation

The center of earth observation in Nigeria is located at NASRDA, the National Space Research and Development Agency, where the federal government of Nigeria is also making major investments in space technologies. Much of this investment is focused on the application of space-based technologies for infrastructure planning, disaster response, and support of long term economic development. With its international partners, Nigeria is responsible for launching the first satellite ever operated by a Sub-Saharan African government – the Nigerian Earth Observation Satellite “NigeriaSat-1” –

launched in September 2003 (using an Indian launch vehicle). This was followed by the Nigerian Communications Satellite “NigComSat-1” in April 2007 (using a Chinese launch vehicle). Nigeria is planning to launch a third earth orbiting satellite, NigeriaSat-2, in July of 2009. Thus far, NASRDA has purchased much of the technology for these microsatellites from Surrey Satellite Technology Limited (SSTL) of Guildford, England. SSTL is 80 percent owned by the University of Surrey.

Geospatial Research and Applications

The GDEST team saw evidence of considerable commitment to university education on the part of Nigeria’s government. For instance, the team toured new computer laboratories, digital libraries, and multi-media rooms in the Federal University of Technology (FUT) at Minna. The team documented a number of research efforts being conducted by faculty at FUT, where projects used NigeriaSat-1 data for monitoring watersheds, land use and land cover change, and other applications of geospatial science and technology. Geospatial research and project implementation is aimed at ensuring that Nigerian scientists are using the data streams being made available by NASRDA and NigeriaSat-1 in order to contribute to the country’s socio-economic development.

The team also saw several excellent examples of Nigerian government investments in geospatial technology applications by state and federal authorities. This included the implementation of one of the most modern cadastres anywhere in Africa at the capital district’s Abuja’s Geographic Information Systems (AGIS) and the new GIS laboratory at the Nigeria’s National Emergency Management Agency (NEMA).

In 2003, Nigeria established the Abuja Geographic Information Systems (AGIS). Within three years, the project completely computerized all the cadastral and land registry information of the Federal Capital Territory (FCT) and revolutionized Land Administration and other land-related departments. Spatial data bases have been constructed using high-resolution satellite images that are ingested in state-of-the-art geographic information systems for easy query, analysis and update. Thanks to AGIS, all decisions concerning land use, urban planning, and infrastructure development for Nigeria’s capital city can now be made from an informed position using reliable and up-to-date data. AGIS can be a useful model to bring to other African capitals in order to demonstrate the power of geospatial science and technology in addressing many of the challenges faced by expanding African megacities.



Dr. Lee Schwartz is welcomed at Nigeria’s National Emergency Management Agency.

Data Gaps, Requirements and Coordination

There is considerable dialogue among Nigerian agencies about the design and implementation of the Nigerian National Spatial Data Infrastructure (NSDI) law. Officials at NASRDA and NEMA referenced Nigeria's NSDI multiple times in discussions with the GDEST team. Nigeria's NSDI policy will serve as a road map for geo-information production, management, and dissemination by all levels of government and the Nigerian private sector. NSDI is seen as a way to streamline interaction between space technology and its overall objectives of improving access to multiple basic services by the Nigerian population. NSDI policy is a fundamental component in the country's overall ability to harness information and communication technologies (ICT) to support the nation's economic development aspirations. Nigeria has been instrumental in pushing an SDI vision within the Committee on Development Information Science and Technology (CODIST) of the United Nations Economic Commission for Africa (UNECA).

CODIST is one of the seven subsidiary bodies of UNECA. As such, CODIST provides policy and technical guidance for the sub-program on harnessing information for development. CODIST's Geo-information Subcommittee (CODIST-GEO) has consistently worked to encourage African member states to support the development of African SDIs as a necessary infrastructure for socio-economic development. Nigeria has been active in supporting CODIST-GEO by trying to ensure that geospatial information permeates every aspect of African development plans. Nigeria has succeeded in including many of the principles of CODIST-GEO in the African Union's New Partnership for Africa's Development (NEPAD) initiative.

Nigeria began drafting an NSDI plan in 1996. Since then, the Ministry of Science and Technology established a 27 member national committee, with sub-committees and working groups, to supervise geographic information policy implementation. These working groups are addressing the different dimensions of SDI development, including legal and institutional procedures, data standards, interoperability, and regulatory frameworks related to the capture, storage, use and distribution of geographic data. The government clearly has a long-term commitment and desire to learn from the U.S. experience.

Geospatial Science and Technology (GST) Collaboration

The options for collaboration on Geospatial Science and Technology (GST) in Nigeria are impressive, including: government agencies and programs, academia (at undergraduate and graduate level), civil society (at the city, state and federal levels) and the private sector (multiple sectors of the Nigerian economy are interested in these technologies). The information communication technology (ICT) infrastructure of the Nigerian economy is evolving and expanding rapidly. For example, Nigerians are rapidly connecting to the Internet with the fast growth of cell phone and computer networks.

RECTAS, located in Ile-Ife on the Obafemi Awolowo University Campus, was established by UNECA in 1972 with a mandate for training, research, consultancy, and advisory services in geo-informatics. It has a regional focus, extending its impact in training and capacity-building to the current RECTAS member governments of Benin, Burkina Faso, Cameroon, Ghana, Mali, Niger, Nigeria, and Senegal. RECTAS provides theoretical and practical training in the field of geo-informatics, integrating

photogrammetry, remote sensing, geographic information systems, cartography, and airborne geophysical surveys. It offers a broad spectrum of teaching opportunities in a wide field of related topics in geo-informatics, including undergraduate and graduate degrees, seminars, workshops, and short term courses. RECTAS also conducts studies and research and provides advisory and consultancy services on geo-informatics matters. RECTAS is well-positioned as a partner institution for developing partnerships and collaboration in geospatial sciences and technologies in Nigeria.

In addition, the exchange of experiences on NSDI development (noted above) is another promising area for U.S.-Nigerian collaboration. This collaboration could yield lessons and solutions that could be applied well beyond Nigeria and West Africa to the rest of the continent.

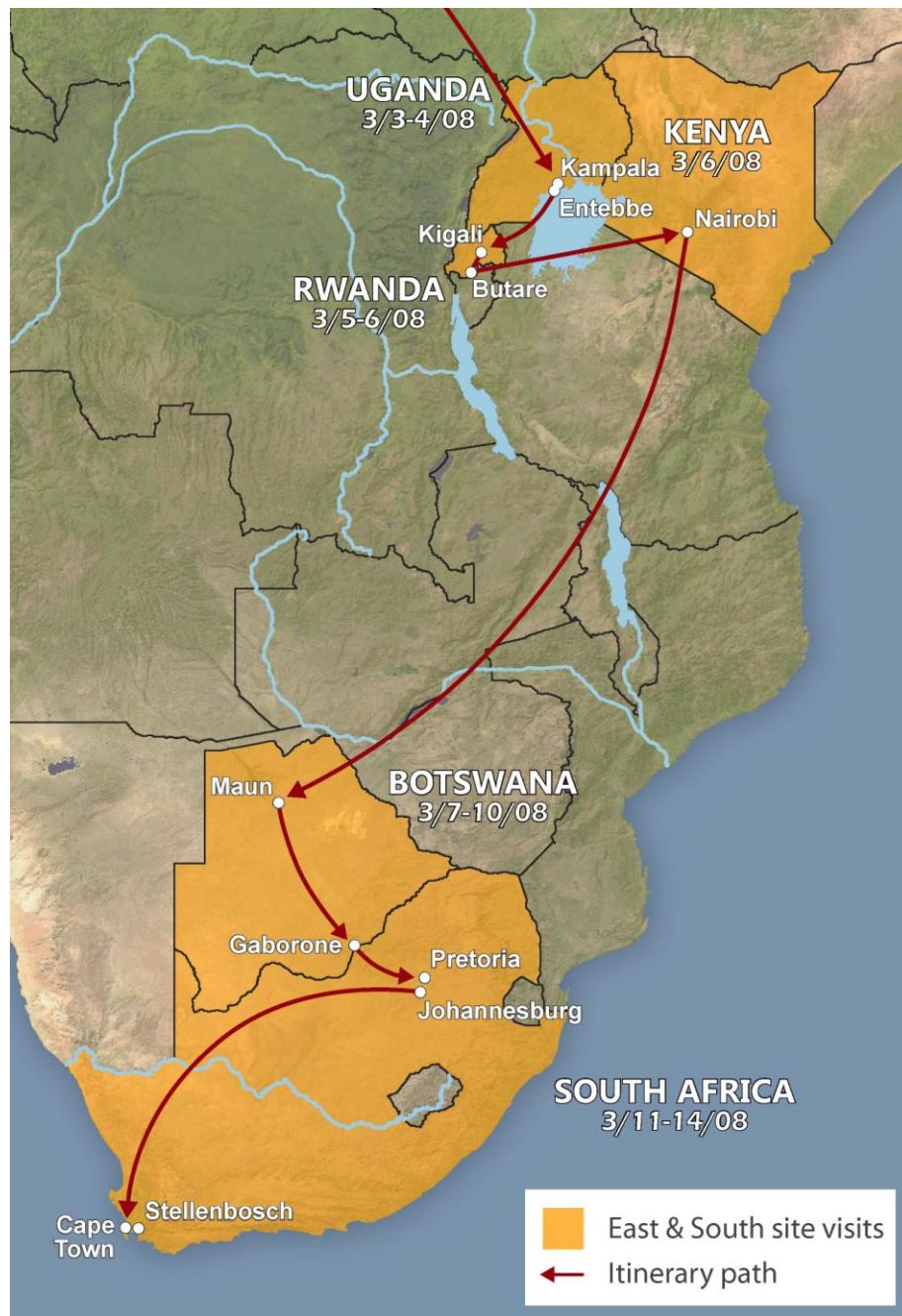
Summary Findings

Nigeria has sub-Saharan Africa's largest potential consumer market and is economically and politically important in West Africa. Its vast oil and natural gas reserves offer more financial resources than almost any other African country for investment in developing the country's science and technology infrastructure, including information, communication, and geospatial technologies. The government is making large investments in education, science and technology, especially in space and ICT. This opportunity becomes more promising when one adds Nigeria's well-educated elite and its enterprising spirit. Because of Nigeria's regional economic and political importance, the U.S. has special strategic interests in the country. Nigeria's considerable financial and human resources offer the U.S. unique opportunities for collaboration and engagement in geospatial science and technology.

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Team East Country Visits: Overview



UGANDA

Uganda is the capstone of the African Great Lakes region, possessing or sharing four of the largest lakes in the continent with Lake Victoria being the most prominent. In spite of the prominence of water resources, the country is landlocked and depends upon ports in Kenya, Tanzania, and South Africa for most of its foreign commerce. The current administration has brought political and economic stability to much of the country. This relative stability has facilitated a constant improvement in the economy and overall infrastructure in the country. Public services are improving, but remain largely concentrated in urban areas, and struggling to keep pace with a population growth rate of 3.1 percent a year. Despite the fact that Uganda has experienced annual increases in its GDP of between five and six percent since the year 2000, a third of its population of approximately 32.4 million continues to live in poverty.

Uganda is largely self-sufficient in the production of key foodstuffs and overall food production continues to increase, but per capita food production is decreasing. Uganda's birth rate is presently among the highest in the world, and more than half the population is under the age of 18. Furthermore, Uganda has largely turned the corner on the HIV/AIDS epidemic. As a result, life expectancy rates are rapidly increasing and have begun to surpass levels prior to the onset of the epidemic.

A number of challenges continue to face the country. Agricultural yields are flat and represent a major constraint to increasing per capita food production. As a result, there is increased pressure on land, water, and biodiversity resources. The government has established a policy and institutional framework to address these issues.



Central Kampala during rush hour.

All Ugandan efforts related to geographic information systems are hampered by a set of common constraints: (1) chronically insufficient resources, particularly in terms of human resources and computer support systems, (2) too much dependency on assistance funding, (3) generational bureaucratic infighting for program control, and (4) a lack of clear political commitment to funding core programs. Despite these constraints, the GDEST team identified noteworthy success stories and possible collaborative opportunities, both bilaterally and regionally.

Earth Observation

Uganda lacks a dedicated center for remote sensing, though various agencies and institutions use remotely sensed data in their analytical efforts. The Urban Harvest Program, an initiative by the Consultative Group on International Agricultural Research, has employed imagery to map peri-urban land use, and the Uganda Bureau of Statistics used imagery to map urban areas. The Urban Harvest program and the National

Environmental Management Agency (NEMA) combined satellite imagery, community mapping, and participatory rural appraisal techniques to incorporate local knowledge in decision making and analysis.

Access to remotely sensed data, particularly to satellite imagery remains an issue. Several institutions do make use of the Landsat imagery which was provided to UNEP by NASA, although this imagery only covers the period 1986-2000. The newly adopted policy of providing free access to the Landsat archives will be extremely useful. Although the government is a contributor to the Regional Centre for Mapping Resources for Development (RCMRD) in Kenya, various government agencies do not have reliable access to such data. NEMA officials expressed frustration that they were unable to obtain current satellite imagery to determine the scope of the September 2007 flooding in the north. It took nearly three weeks to obtain a free download of MODIS (Moderate Resolution Imaging Spectroradiometer) data in this case, and the resolution was not sufficient to be effective for planning a response to the disaster. Additionally, access to near real time imagery would be of particular use in tracking water hyacinth blooms in Lake Victoria and to forecast disease outbreaks that may be indicated by climatologically, hydrological, or vegetative data derived from such imagery.

Geospatial Research and Applications in Uganda benefits from an institutional framework that can address a number of key issues related to sustainable development. NEMA uses GIS to prepare a State of the Environment (SoE) report every two years and a district report every year. The government performed assessment mapping and developed hazard maps for earthquakes, landslides, floods, and drought for use by the Department for Disaster Preparedness and Management. The 2007 flood response highlighted the need for an appropriate institutional framework to engage disaster response organizations in areas of expertise that can contribute to such responses.

Geospatial science and technology applications are in evidence at the local level as well. The Urban Harvest program engages in local decision-making within the context of its research zone. This is accomplished through participatory processes that engage the local community and apply mapping approaches. Generally, one of the challenges to efforts such as this initiative led by the Consultative Group on International Agricultural Research (CGIAR) is their ability to link policy to on-the-ground results. Similar approaches have been applied by NGOs working at local levels to feed into the NEMA State of the Environment reporting process.

Water management has acted as a driver in the application of geospatial science and technology. Almost wholly within the Nile Basin, most of Uganda's water resources are shared with other countries and governed by a number of agreements and conventions. When doctoral research found the Kageri River responsible for bringing sediment to Lake Victoria, Rwanda and Burundi were subsequently included in the Lake Victoria Environmental project. Additionally, the Nile Basin Initiative (NBI) strengthened established linkages between science and policy, although the science could be.

The Uganda Bureau of Statistics (UBOS) developed a Rockefeller Foundation-funded Local Government Information and Communication System (LOGICS) to generate data for use by decision-makers and businesses. Data are in high demand, and increasingly needed for use in elections, education planning, HIV service provision, distribution of mosquito nets, and business intelligence in such areas as cell phone tower placement.

USAID has made a contribution through its Productive Resource Investments for Managing the Environment — Western Region program (PRIME/West), which seeks to sustainably and equitably integrate the region's economy and people into the global economy. Using GIS the project merges landscape analysis with economic competitiveness so locals earn an income while ensuring sustainability. The project's first component, landscape analysis, is a systematic analytical and planning process that examines specific economic opportunities available to people in southwestern Uganda. The project's second component, economic competitiveness, ensures that activities are economically viable at household, community, and regional levels.



Dr. Robert Swap, Mr. Jason Bourisaw, and Dr. John Kelmelis with Makerere University faculty.

One of the greatest issues expressed by numerous senior managers and scientists regarding GIS information is trying to visually represent what is happening over time to decision-makers and policy makers within Uganda. NEMA specifically mentioned that they would like to develop the capability of conducting trend and scenario analysis as part of their State of the Environment reporting. Although they have trained GIS staff, these individuals lack the modeling skills to make this possible.

Further, there appears to be an opportunity to extend the use of geospatial science and technology to the local level. Since Uganda began its decentralization process in 1993, local government and institutions in Uganda now have a key role in influencing land management at the local level. Both the NEMA and the National Environment Action Plan (NEAP) rely upon local institutions for support and implementation. If local skills could be developed to apply geospatial science to these issues, the locally-driven decision making process could be enhanced.

Data Gaps, Requirements, and Coordination

Data interoperability is a common problem among organizations involved in geospatial applications. Presently, consistent coverage among geospatial themes collection dates is lacking and may stem from the project-based nature of data collection and use. Further, budget constraints have caused erratic appropriations that change from year to year. In addition, very little of the necessary reference data are collected on the ground. For example, stream gauge data or meteorological data in a spatially-representative framework would enable predictive spatial modeling or advance warning of flooding events in Uganda. Distributed imagery depends upon sufficient broadband, which is frequently lacking, and imagery remains expensive for initial purchase.

UBOS's technical capacity appears excellent, although both census projects and publications depend partly on foreign assistance. UBOS wants to become a center of excellence for statistics in Africa by serving as a geospatial hub, or information

repository for African census data, to improve data sharing and access. It is unclear how soon this could occur in practice, since UBOS has little internet presence. Improvement in processes and products could come through discussion with other countries, for example, via the UBOS Director's role as chair of the East African Regional Census Committee.

Makerere University is playing a leading role in improving spatial data infrastructure at the national level. In June 2006, it organized a national spatial data infrastructure workshop and initiated a GIS association. Institutional rivalries stymie the effort. The university's Institute of Environment and Natural Resources (MUIENR) serves many government institutions that include, inter alia, the National Environment Management Authority, the Forest Department, the Uganda Wildlife Authority, the Wetlands Program, and the Lake Victoria Environmental Management Program. The Center supports its clients by producing maps and applied analysis for the central and district government authorities. Using a Rockefeller Foundation grant, MUIENR started GIS training for district and local government analysts. Furthermore, there is evidence that the national geospatial market is able to absorb students after graduation.

Geospatial Science and Technology (GST) Collaboration

Collaboration on GST takes place at various levels; local, national, regional, and international. The GDEST team did not observe any local collaboration, but was informed of collaboration between communities and NGOs, research centers, and governmental partners through participatory and community mapping efforts.

Interagency and national collaborative efforts are largely issue- or project-driven. Extensive collaborative activities take place between the Department for Disaster Preparedness and Management and other government agencies and with international and regional organizations. The fact that the Department is located within the Office of the Prime Minister (OPM) greatly facilitates interagency coordination of activities. The OPM links multiple ministries responsible for various facets of disaster preparedness, and an Inter-Ministerial Committee on Disaster Risk Reduction and Management has been established to help with this process. There is also donor dialogue on natural resources management with data management issues being raised and the possibility of a basket fund under the Ministry of Finance.

Collaboration structures include the Inter-University Council of East Africa and the University Network for Disaster Risk Assessment. Inter-departmental collaboration takes place under the Urban Harvest initiative between the Departments of Geography and Social Science at Makerere University; Makerere University also collaborates with the University of Dar es Salaam in Tanzania and the University of the Witwatersrand in South Africa. The NBI could benefit from links to other activities within the region as well as internationally. NBI staff is interested in linking up with the Association of American Geographers. Entebbe NBI center staff is also quite surprised to learn of existing capabilities in Kampala in MUIENR at the Makerere University as well as those capabilities associated with the Urban Harvest and PRIME/West activities.

Summary Findings

The team observed that there is nearly a critical mass of dynamic mid-level managers and emerging students who will champion the acceptance of geospatial science and technology in decision-making processes. The team met with various members who form a cadre of like-minded people who were educated together and now populate government and the NGO community. This group appears to have growing influence in policy-making and decision-making levels of the Ugandan government.

However, the team found that all Ugandan GIS efforts are hampered by chronically insufficient resources, including human and computer support systems, as well as too much dependency on assistance funding, generational bureaucratic in-fighting for program control, and clear political commitment to funding core programs. Despite these findings, the team identified some success stories and possible collaborative opportunities, both bilaterally and regionally.

The team recommends that the Department for Disaster Preparedness and Management communicate with U.S. Government agencies to explore options for meeting some of its emergency response imagery data needs. The team also observed that some of the needed rapid disaster assessment data could be collected by aerial or ground-based GPS/GIS field data collection systems. Of course, obstacles to using these data sources and products effectively in preparing for and responding to disasters in Uganda include the current lack of sufficiently trained technical personnel, equipment and related digital data infrastructure.

The success that Uganda has achieved in developing human capacity at national (central government) levels needs to be extended to local levels. This problem is particularly acute since districts have the responsibility (and authority) to prepare annual environmental assessments and development plans. NEMA has difficulty devoting more staff time to training for building additional capacity. Moreover, those who have been trained at the district level tend to move on to other opportunities elsewhere. As a result, the central agencies such as NEMA and UBOS who rely upon local data collection efforts have difficulties in assembling the data they need.

Some sources of deeper cooperation could include AAG membership, the Nile Basin Initiative, Embassy Science Fellows, and Fulbright Scholarships. USAID agriculture programs could play a significant role. USAID's SERVIR program, imported from its prototype implementation in Latin America, can be directed toward biodiversity conservation.

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RWANDA

Rwanda stands out for the progress it has made in rebuilding its economic and social infrastructure since the end of the 1994 war. This agrarian nation of 10.5 million people has been enjoying steady economic growth in recent years, principally through export of high quality agricultural products and thanks in large measure to the generous support of foreign donors and international lending institutions. The population density (one of the highest in Africa) by unit of arable land results in high competition for arable land in most regions of the country. Today, almost 80 percent of arable land is regularly cultivated and soil deterioration is reaching alarming levels.

Since 2004, the government has focused on a modern science, technology, and innovation (STI) policy to carry Rwanda into its next development phase. Indeed, the president has emphasized e-government by insisting on a “paperless” process for his administration and communicating almost exclusively by e-mail with all his ministers. Cell phones are ubiquitous among the leadership and increasingly affordable to urban and village populations.



Among many specific areas and issues, the STI strategic plan highlights the central role of ICT and “geo-information,” assets that are featured in all subsequent economic policies developed or being developed by the government.

Intensive agriculture on small holdings in the Rwanda countryside.

The team believes Rwanda is making great progress in the GIS and remote sensing (RS) field, with some significant impacts rendered in policy development and decision-making, but is concerned about over-dependency on donor funding for many programs. Notwithstanding the top-down leadership of the current president, there is an urgent need to set uniform standards for geospatial information and to ensure consistent data archiving and access to all stakeholders, including the NGO community and private companies and entrepreneurs. On the ICT front, the country has undergone a rapid turnaround from a technologically deficient country to one in which all government business is conducted online. Even the parliament has computer screens at all seats. While many African countries still are in the process of drafting national information and communication infrastructure (NICI) plans, by 2005 Rwanda already had reviewed the implementation of its first five-year NICI plan and had prepared a second plan (NICI II).

Progress can be attributed to a confluence of factors, but in particular to political leadership and high-qualified political appointees. Leadership sets Rwanda apart from other African countries. President Paul Kagame is known as an ICT champion, actively promoting e-government and the development of IT in the country. His commitment enabled Rwanda to mobilize substantial financial resources. Also, Rwanda has orchestrated an injection of external human resource expertise (Rwandan ‘returnee

refugees’ as well as both Rwandan and international expatriates). This influx is socializing the government to do its work in new ways.

Earth Observation

Rwanda has emerged from its civil conflict having lost most of its intellectual capability. The remote sensing community is not an exception. Aside from CGIS-NUR, there is no institution positioned to acquire, store, disseminate and use remotely sensed imagery. Further, Rwanda is not a member of RCMRD, thus limiting its access to regional data. Monitoring and modeling using geospatial technologies is quite limited, but education in geospatial science is part of the “big push” to promote higher education in the country.



Headquarters of the Rwanda Development Gateway in Butare, Rwanda.

The Center for Geographic Information Systems and Remote Sensing (CGIS-NUR) at the National University of Rwanda is establishing a receiving facility for MODIS and Meteosat imagery. This may be the only such facility in the country.

Geospatial Research and Applications

The Coffee of the Thousand Hills project is an excellent example of GIS working to support decision-makers in government and agriculture. The model takes into account many spatial variables to divide the county up into coffee “sectors”. The results will help guide decision-makers in future development with the goal of establishing Rwanda as a high quality coffee producer.

CGIS-NUR is also involved in a number of activities involving geospatial science and technology. They are working on or have recently conducted programs to map forests in Rwanda, to establish a GIS database for the Kagera Basin, develop a zoning plan for the Akagera and Volcano National Parks, and to develop the Rwanda Development Gateway.

Data Gaps, Requirements, and Coordination

The Rwanda Information Technology Authority (RITA) has established a National Task Force on GIS to coordinate development of GIS/RS in Rwanda. RITA’s focus remains more on “classic IT” rather than geospatial applications.

CGIS-NUR, an inter-faculty unit, is developing a GIS and RS curriculum for instruction and assisting national institutions by providing training in the application of GIS tools to current problems in Rwanda. They also are establishing links between universities, research institutes, government, and non-government organizations to improve data sharing and the coordination of activities, and efforts to establish a geospatial metadata/data portal. CGIS-NUR intends to start a GIS master's program in 2010. They have nine full time staff, five of whom are in training, plus 12 associated part-time researchers. Since a Rwandan geospatial private sector barely exists, CGIS-NUR will be greatly challenged to build up the industry. However, the NICI and government priority to increase use of ICTs generally can raise the potential for success if CGIS-NUR resource requirements are also included in the strategic plans.

The Ministry of Lands, Environment, Forestry, Water and Mines is working on the major issue of land reform. The ministry created a National Land Centre (NLC) to oversee and coordinate land administration and management in Rwanda. Minister Patricia Hujabakiga, said her presentation of the National Land Centre idea at the President's mid-February 2008 cabinet retreat was well received. However, at the time of the team visit this issue had not been settled and debate continued for both centralization and decentralization approaches. The Ministry of Agriculture and Livestock (MINAGRI) is the custodian of a critical national database, which is difficult for others to access. The digital soil database of Rwanda, at a scale of 1:50,000, and the result of 30 years of collaborative work between MINAGRI and Belgium, was transferred to MINAGRI with other related and derived information concerning climate, agro-climatic regions, and elevation contours for Rwanda digitized from the 1:50,000 scale topographic map of Rwanda.

Geospatial Science and Technology (GST) Collaboration

The team identified several areas to foster deeper collaboration with Rwanda and its neighbors. Based on successful precedents, additional Embassy Science Fellow assignments were invited to address GIS/RS needs. Fulbright fellowships and/or faculty and student exchanges can be investigated. AAG offered Rwandan counterparts free access to its assets for distant-learning and training. The team also encouraged government participation in the new SERVIR node being organized in Africa as well as deeper collaboration with Ugandan counterparts on the Nile Basin Initiative, managed in Entebbe. Finally, USAID has other possible areas for increasing support, such as sustainable agriculture, soil mapping, and watershed management, where GIS data and analysis can provide strong policy and decision-making support. In this context, the team was preparing to follow up with the World Bank Office of S&T and Innovation, which recently published a seminal report that examined innovation potential for food processing, agricultural research and outreach, delivery of clean water, and geosciences and geothermal energy, areas in which geospatial data and analysis are critical tools.

Rwanda needs support on SDI strategy, particularly standards and business models. RITA only has two people dedicated to GIS out of a staff of 80. RITA is working with CGIS-NUR on building GIS skills and capacity in ministries, creating a clearinghouse, and formulating SDI strategy. SERVIR may be a resource for training and metadata, particularly by working through the RCMRD. One possibility would be a follow-up on a workshop in Rwanda to encourage formation of a regional geoportal. RCMRD may gain from this if the government agreed to become a member of this regional body. The AAG

may follow-up through membership and human capacity-building efforts, in a collaborative arrangement with regional associations.

Rwanda is encouraging GIS in schools (Botswana is doing this as well, generating an opportunity to learn from each other's experiences), which could be linked with the U.S. Global Learning and Observation to Benefit the Environment (GLOBE) program. GIS should support/enable potential investors as well as environmental impact assessment. One potential research topic for an economist is an assessment of GIS on the coffee project to the economy as well as to determine the opportunity cost for not having data more readily available (e.g., MINAGRI soil database). Rwanda is in a strong position because of its bilingual status (French/English) to bridge the East/West African linguistic divide.

Summary Findings

At this stage much attention in Rwanda is given to mapping fundamentals and thematic datasets, as opposed to more sophisticated modeling and spatial analysis. The lack of sufficiently qualified scientists means a reliance on short-term expatriate appointments. CGIS-NUR currently has a problem with staff retention--a geospatial practitioner with a master's degree earns approximately half the salary of counterparts in other non-academic sectors. Staff receiving training commit two years to CGIS-NUR, but rarely stay longer.

Rwanda has laid optical fiber to the border, but it is at the mercy of Kenya and Tanzania to obtain a connection to the coast. The government is moving ahead on internet, with 90 buildings connected. The University of Butare has VSAT, but through a private provider. Lack of fiber optic cable is preventing web mapping.

NUR would be well-served if it could strengthen its curriculum for GIS specialists, while the same could be said for CGIS if it could broaden its base of funding and widen its human resource base.

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KENYA

Kenya represents a key economic and political anchor in East Africa. National income remains highly dependent upon natural resources. Economic growth has stagnated (though in recent years GDP growth has reached as high as seven percent), and the political structure is entrenched. Unemployment hovers at 40 percent, and half of population lives below the income poverty line. Kenya has experienced rapid growth in its population, averaging nearly three percent per annum for more than a decade and now standing at 39 million people. As a result, the population structure is skewed towards the youth. With limited employment opportunities, this situation creates conditions for increased civil unrest.

Kenya also faces a number of significant environmental challenges. Demand for agricultural land by its rural population creates tension between ethnic groups. It also creates tension between the agricultural sector and its primary income earner of tourism. Increased land pressure has threatened the biodiversity upon which the tourism sector depends. Climate change is increasing



Team East with geospatial experts in Nairobi.

the risk of drought and agricultural uncertainty, as well as the potential for climate-related conflict. Already, significant ethnic conflict exists in pastoral areas and along the boundaries between sedentary farming communities and pastoral communities.

Kenya has several well-established universities, particularly Jomo Kenyatta University and the University of Kenya--all with strong academic programs, including geography.

With its central political role in the region, Kenya hosts several regional and international organizations that play major roles in the application of geospatial science and technology in the region. Nairobi is the headquarters for the UN Environment Program and regional headquarters for the other major UN organizations. It also acts as headquarters for the UN mission to Somalia, which has significantly contributed geospatial information use in the region. Nairobi is one of the headquarters for the International Livestock Research Institute (ILRI, part of the CGIAR), the Regional Centre for Mapping Resources for Development (RCMRD), and the Intergovernmental Group for African Development's (IGAD) Climate Prediction Center. Kenya also hosts satellite telemetry tracking facilities for NASA and a receiving station operated by Italy in Malindi. Kenya is a key member of the African Resource Constellation satellite program.

Because of post-election unrest in Kenya, the team was unable to visit individual institutions. However, the team did manage to meet with representatives from key institutions engaged in geospatial science and technology during an afternoon stopover at the Nairobi airport. The following sections summarize that meeting

Earth Observation

Kenya enjoys a relatively strong capacity in the use of remotely sensed data. The RCMRD is perhaps one of the strongest data centers in Africa and offers analytical as well as training expertise. In addition, IGAD Climate Prediction and Applications Centre (ICPAC) receives meteorological data through a NASA link and issues periodic climate analyses largely targeted at the agricultural policy community. Similarly, FAO and the USAID-funded Famine Early Warning Network (FEWS NET) conduct periodic analyses of vegetation data in their food security and hunger vulnerability assessment in the region. Nevertheless, most of the data holdings of imagery are project-related, and they do not have ready access to high resolution image data. Structures for data archival and distribution are nonexistent. Nevertheless, the RCMRD possesses the historic Landsat images provided to UNEP and has created national data sets for distribution.

Geospatial Research and Applications

Kenya is fairly sophisticated in geospatial information science and technology. Organizations are either part of donor groups or receive funding from donors, either government or non-government. If external funding declined there could be a sudden decline in the sophistication of the geospatial science and technology community in Nairobi. The presence of international research centers, such as ILRI and regional data centers, such as the RCMRD and ICPAC, has resulted in Kenya serving as a hub of modeling expertise. Developing an understanding of how to make these scientific communities sustainable at the appropriate level would be valuable.

Regional demand for these modeling and analytical services is quite high. UNEP engages a number of these institutions to conduct analyses. Further, ILRI has a very strong funding base and conducts wide-ranging analyses with a strong geospatial component. The government has a relatively robust geospatial capacity, particularly in its wildlife and agricultural divisions. Kenya also maintains a food security unit closely tied to regional units, as well as FEWS NET.

Data Gaps, Requirements, and Coordination

Kenya's 2002 national development plan incorporated an initiative to establish a national spatial data infrastructure. Also, there are other networks such as the Institution of Surveyors of Kenya (ISK), and Kenya ESRI (Environmental Systems Research Institute) User Group (KUG). Despite organizations indicating willingness to share, there is a general inertia or even outright resistance to change, lack of customer orientation and a culture of hoarding, and resistance to sharing data and information. A strengthened network of professionals and establishment of channels for information exchange is necessary. This networking has previously been fueled by the spatial data infrastructure dialogue. However, it may be more appropriately driven by a process by which a national structure of baseline data layers would be established. This could be facilitated by a regional entity, such as EIS-Africa's engagement in the Mapping Africa for Africa (MAFA) process and in collaboration with RCMRD, which could be the natural host for such data.

University curricula in the disciplines of computer science, geomatics, engineering, surveying engineering, or surveying technology could be strengthened to require additional specialized training for students. Furthermore, geospatial professionals lack channels to keep abreast with changing demands in industry and the wider business sector. One means of doing so would be to maintain a series of accredited short course programs conducted within the framework of continuous professional development (CPD).

Geospatial Science and Technology (GST) Collaboration

Given the critical mass of geospatial specialists and dedicated institutions in Nairobi, one would anticipate that the opportunities for collaboration are numerous. However, such is not necessarily the case. Often, these activities proceed in relative isolation and occasionally in an atmosphere of competition. Nevertheless, the professionals within the network are familiar with each other. If an appropriate mechanism with an adequate level of trust were developed, collaboration could thrive. One means of doing this would be to engage USAID to ensure that data products from its projects are discoverable through an appropriate portal. A second would be to generate a series of geo-information success stories in a collaborative fashion that engaged a wide range of actors from within Kenyan geospatial circles.

Summary Findings

Kenya boasts a strong geospatial community by virtue of it being a hub of regional and international organizations involved in environmental and humanitarian efforts. The RCMRD, in particular, offers considerable capacity to host data and provide training.

The absence of a vibrant and functional professional association greatly undermines NSDI development in Kenya. Such a professional body could advise the government on geo-information issues, support GIS education, facilitate linkages with international GIS industry, promote GIS awareness, and unify the profession.

Downloading data is a commonly expressed constraint nationally, particularly at the village level. Dr. Ogallo (ICPAC) noted that it is time for methods to be developed to provide geospatial information to the uneducated rural population in a way that it can better use the data. More than just access to raw data, the user community is desperate for interpreted data, and outputs from modeling efforts in the form of high quality support products for decision-making.

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BOTSWANA

Botswana represents a relatively unique blend of strong democratic and economic institutions that have made it somewhat of a model for development among African countries. Botswana's economic development trends in many ways more closely resemble the oil-rich Gulf States than the rest of Sub-Saharan Africa. Macroeconomic stability, a relatively small population of just under 2 million people, and prudent use of diamond export earnings have catapulted Botswana to its current status as an upper middle-income country. Efforts to create a more diversified economy have so far had little success, with mining – principally diamonds – accounting for a large share of domestic output and almost all exports. The government remains committed to reducing dependence on mining and recently initiated new measures to improve the business climate and export competitiveness in other commodities and light manufactures.

The HIV/AIDS pandemic remains the biggest threat to human development and economic growth. The proportion of HIV-infected people is one of the world's highest. However, some progress is being made through greater access to antiretroviral drugs.



Central Gaborone, Botswana.

Botswana's future water demand will necessarily be met by utilization of shared watercourses, because available water resources inside the country may be insufficient to meet future demand projections. Thus, participation in trans-boundary water resource management is one of the government's priorities, since most of the country's major rivers share courses with neighboring countries.

The government's capacity for geospatial applications is threatened by a loss of staff to the private sector. For instance, at the Department of Geology Surveys (DGS), funding is available but organizational capacity is insufficient to complete projects. DGS cannot retain personnel due to low government pay.

Earth Observation

Earth observation efforts in Botswana tend to be more project-related and ad-hoc rather than strategic or coordinated in nature. However, there is an increasing interest in obtaining satellite imagery and developing the capacity for its use. The Department of Surveys and Mapping is preparing to make a fundamental change in acquiring source data by using QuickBird imagery. The goal is to migrate from historic aerial photography to more current satellite imagery.

Analytical capacity exists, though primarily in research and academic institutions. For example, the Henry Oppenheimer Okavango Research Centre (HOORC) is internationally known for its research focusing wetlands and hydrological modeling and its scientists publish in peer-reviewed journals. HOORC is interested in expanding its

scope to natural resource management, including environmental monitoring, and trans-boundary conservation issues.

The University of Botswana, based in Gaborone, is another source of expertise, particularly in terms of capacity development. However, GIS/RS is rather weak. The curriculum in the Department of Environmental Sciences tends to be more technical, but is currently more oriented toward applications. The Diploma course in geomatics in the Engineering Department, however, is almost exclusively technical in nature. The University of Botswana plans to establish a full secondary campus in Maun and increase the number of students to 4,500 by 2015.

Geospatial Research and Applications

Several advanced applications of geospatial science and technology are being implemented in Botswana. However, a gap remains between scientific application and incorporation in the decision-making process. For example, the GIS-based Okavango Delta Information System (ODIS), developed by HOORC, is used for planning and decision support, in particular for the Okavango Management Plan. The Ministry of Environment, Wildlife and Tourism contracted HOORC to integrate data from different government agencies and from NGOs so that information products could stimulate policy discussion--a clear case where the government invested in geospatial technologies for policy development. Many agencies have received the ODIS on CD.

The Ministry of Environment, Wildlife and Tourism has a plan underway to develop a GIS-based Environmental Information and Management System (EIMS) for Botswana. The ministry hopes to use EIMS data to identify trends to inform local and national-level policy and decision-makers. Once EIMS is up and running, the ministry's ability to influence governmental decision-making may be improved. Ministry personnel are clearly committed to addressing national needs and it seems likely that they will begin to at least indirectly influence policy.



Maun, Botswana, seat of the Harry Oppenheimer Okavango Research Center.

The National AIDS Coordinating Agency (NACA) has evidently influenced decision-making on health policy, and gained government support, as shown by Botswana's success in providing anti-retroviral treatment drugs to 90 percent of the infected population. Treatment and education programs are beginning to succeed, with lower infection rates in younger age groups. Further influence will come through adoption of GIS methods to identify areas where there is a mismatch between HIV infection numbers and clinic locations.

The USAID and the Swedish International Development Cooperation Agency (SIDA) supported Okavango River Basin Commission (OKACOM) Secretariat has science-

related working groups (e.g., biodiversity, hydrology) whose dialogue is meant to feed into political decisions. Generally, OKACOM focuses on management issues, training, and data management with less focus on research itself.

The Botswana Institute of Development Policy Analysis (BIDPA) is the primary economic think tank for Botswana. Staff does not currently work with geospatial data, but it has an interest in understanding GIS tools to study disaster relief, mining, and other areas with a spatial component. BIDPA probably has a major influence on decision-making, both through its largely government-funded reports, and training activities.

Overall, there is much talk about introducing science and technology into planning. The current Minister of Science and Technology is active, but it is not clear how much she influences other ministries or the cabinet. Unfortunately, the food security and early warning cultures that developed in the 1980s have disappeared due to the lack of government support. Investment in early warning systems is treated as a one-of, donor-reliant initiative. Significant funding for long term partnerships and equipment is needed.

Data Gaps, Requirements, and Coordination

Like most of the government agencies visited by the team, the Department of Surveys and Mapping has issues with government data sharing. The lack of coordination also results in overpaying for ESRI software because each agency purchases its own software rather than sharing resources through government-wide site licenses. On the production side, the lack of resources and slow production rate mean that map products quickly became outdated or are already out of date when completed.

There are many geospatial projects and programs in private organizations, and government departments in Botswana. While some initiatives aim to create an environment that enables a wide variety of users to easily access and retrieve spatial data sets, many are tailored to the specific needs of a particular department or ministry. An overall policy for data management and data sharing is lacking. Furthermore, a generational gap exists as the younger practitioners, who are more willing to share data among themselves, must wait for an unreceptive older generation to retire. However, several ministers appear to be dynamic and proactive (e.g., Minister of Environment, Minister of Science and Technology, and Minister of Education), but the mid-level bureaucracy is problematic.



Andrew Reynolds and Douglas Richardson discuss findings with staff of the Botswana Institute for Development Policy Analysis.

These issues notwithstanding, Botswana is quite advanced in developing spatial data policies. The government established a National Spatial Data Infrastructure in 2002. A National GIS Coordinating Committee (NGCC) was formed with representatives from ten government agencies and the University of Botswana.

A 2007 government policy for cost recovery negatively affected access to and increased the cost of data from government agencies. An organization such as HOORC can no longer obtain data for free directly from the local weather stations, but must now send payment to a central office to obtain access. This process can be lengthy and in some cases, a year can pass before receipt of the data. Data sharing by means of an Atlas of Botswana is considered a useful effort, but some of the informants contacted by the team indicated that the Atlas is outdated and lacks a process for updating.

Geospatial Science and Technology (GST) Collaboration

Botswana offers an excellent environment for collaboration, partly as a function of its willingness to employ or finance foreign scientists to fill gaps in national human resource needs. HOORC has many collaborators and well established relationships with U.S. universities. The primary constraint to broader collaboration is a shortage of accommodations and many more proposals than HOORC can accept.

HOORC is interested in SRTM-derived datasets from 30-meter resolution imagery for which USGS could potentially be of assistance. The Department of Surveys and Mapping could also benefit from a direct source of commercial imagery from National Geospatial-Intelligence Agency (NGA) or USGS channels in a possible bilateral partnership.

NACA seeks future collaboration with the U.S. Department of State Humanitarian Information Unit (HIU) and is open to collaborating with U.S. Census Bureau with respect to data sharing and population projection methods incorporating HIV data. NACA officials feel that their information is more current than what feeds into current UN and U.S. Census Bureau population projections. They did not explicitly ask for collaboration in GIS training, but their GIS effort is just beginning, and digital mapping will be a key component of efficient planning in the future.

Several agencies identified the need to develop updated and more comprehensive national inventories of natural resources. This is an area in which potential cooperation with U.S. governmental agencies might be explored. Also, collaboration opportunities between U.S. public and private entities and the Ministry of Environment appear to be significant.

The Botswana Department of Geological Survey (DGS) has the potential to, for example, collaborate with the United States-led AfricaArray in order to enhance its capabilities (seismic studies, interpretation of seismic data) and capacity (personnel). Also, potential exists for collaboration between DGS and U.S. and local academic experts in historical synthesis of geospatial data (mainly universities and the Library of Congress). University of Botswana undergraduates in the engineering and environmental sciences could benefit early in their academic careers from such links to build both capability and sorely needed capacity. Regional collaboration with academic institutions may also be enhanced. For example, such collaboration could build upon Water-Net, an African inter-university program for water-related training and research. Core courses are taught at the University of Dar es Salaam and the University of Zimbabwe, with elective courses elsewhere.

In general, Botswana could benefit from greater dialogue with U.S. counterparts on information infrastructure activities, particularly with SDI management, data standards, archival techniques and metadata. Perhaps a high-level policy and university finance dialogue could be facilitated. University of Botswana in some ways is a model since the government makes a substantial financial commitment to the university.

Summary of Findings

Botswana has a capable human resource base but not in large enough supply. As a result, some agencies rely heavily upon local and external consultants or put off work that they otherwise could fund. The situation is becoming so tenuous at the Geological Survey that the organization must contract out mapping and other scientific activities, as well as the quality assurance and quality control of that work. In some cases, more specialized expertise is needed, such as in areas of developing rapid response capabilities for fighting remote fires, resource accounting/inventories, and geospatial data management and metadata best practices. The staffing shortage in government in part is due to private sector hiring of government workers. HIV/AIDS is also contributing to the capacity vacuum. HOORC also indicated that they have difficulty getting students of adequate caliber and that the best students tend to go to foreign universities.

Challenges still exist in the area of collaboration and coordination among multiple governmental agencies and ministries. In addition generational attitudes towards technology and limited capacity to digitally exchange data appear to be limiting coordination efforts. HOORC has partnerships with Namibia and South Africa, but indicated that it could improve collaboration with universities in the region. However, basic communication is sometimes a problem. Even though HOORC has good telecommunications infrastructure, including a satellite dish, others often do not, and email messages are not getting through to students and colleagues. Existing collaborations are usually between individuals and not on an institutional basis.

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SOUTH AFRICA

South Africa is a major economic and political driver in Africa, particularly in southern Africa. Per capita income is \$10,400 USD but remains highly concentrated within the richest 20 percent of its population of nearly 49 million people. The primary challenge to development in South Africa has been the post-1994 transition of the political and economic structures. The service sector comprises two-thirds of the economy while industry is nearly a third. South Africa has a strong civil society, with over 2,500 NGOs operating in the country. Opportunities for economic advancement are somewhat constrained by corruption and crime, as well as high levels of HIV/AIDS infection rates – an issue that has only been modestly addressed by government policies.

South Africa has a very robust infrastructure, with an extensive road, rail, and air network. The electricity network is also extensive, but struggling to meet a growing demand as electrification to rural areas and underserved populations has outpaced productive capacity and long-term maintenance has been underfunded. This has led to rolling blackouts that have hampered industrial production and commercial activity. Internet connectivity is relatively strong, and half of the population has access to mobile phones.

Education is relatively strong, with nearly universal enrollment in primary schools. High literacy rates prevail throughout the population and there is a wide range of institutions of higher learning, several of which have international standing. The country is challenged to maintain these statistics in light of high fertility rates that have resulted in people under 15 years of age comprising one-third of the population.

South Africa has had a strong mapping and geospatial science capacity, as well as aerospace capabilities, since the mid-1970s. Government and non-governmental organizations have made great strides in implementing a geospatial data infrastructure and a number of professional organizations are active in the fields of cartography, geography, geomatics, and remote sensing.

Earth Observation

South Africa has maintained a strong capability for satellite imagery collection. A government-maintained satellite receiving station at the Hartebeesthoek Satellite Applications Center (SAC) is run by the Council for Scientific and Industrial Research (CSIR) from which they provide telemetry management for space launches by a number of international space agencies, including NASA. SAC also receives real time Landsat, SPOT, and other imagery.

South Africa also has the capability to manufacture satellites and provide launch facilities. Until the mid-1990's, South Africa possessed military space launch capabilities



Dr. John Kemelis with a mock-up of the SumbandilaSat microsatellite at SunSpace in Stellenbosch.

at Cape Agulhas and maintained a secret satellite assembly facility near Houwteq, in the Western Cape. The government decommissioned these programs and leases the launch facility to commercial and other government space agencies for polar launches. The Houwteq facility has a large clean room and environmental testing chambers at which SunSpace is now producing its second hyperspectral high resolution microsatellite. These microsatellites will form part of the Africa Resource Constellation, of which South Africa is a founding member. Also, the South Africa Space Act established a national space agency and set the agenda for growth of the space industry (including strengthening education in space science and technologies).

CSIR regularly uses diverse sources of remotely sensed data. South Africa has a contract for access to SPOT 5-generated 2.5 meter resolution orthorectified image mosaics. A consortium of government departments and entities support the contract and use the data. Government departments use SPOT data and the data are freely available to all tertiary education institutions planning and research. CSIR has a long history of collaboration with municipalities, national, and international partners. Until South Africa's human resources are augmented, however, progress in regional cooperation will be limited.



Staff members of the Agricultural Research Center in Pretoria, South Africa.

CSIR will provide China-Brazil Earth Resources Satellite (CBERS) data at no cost to all African countries located five degrees south of the equator. CSIR will also use spare capacity on the European Organization for the Exploitation of Meteorological Satellites (EumetSat's Geonetcast), which will allow easy downlink over Africa. The geostationary communications satellite downlinks enable CSIR to deliver images to anyone within its footprint.

CSIR's Advanced Fire Information Service detects fires and emails or sends SMS text messages to relevant authorities. This builds upon the NASA-supported Southern Africa Fire Network operating out of the Goddard Space Flight Center and the University of Maryland. Through the Personal Digital Assistance Animated Weather System (PAW), South Africans can use cell phones to access satellite information on severe storms. PAW provides near real time information on clouds, rainfall, wind, and fires.

South Africa is the current chair of the Group on Earth Observations (GEO) and the government and various universities have collaborated on earth observations initiatives, such as the SAFARI 2000 and Miombo Network that were supported by NASA. Remnants of these efforts remain active, particularly within the university community.

The CSIR Satellite Applications Centre would like to benefit from the development of the South African Space Agency, but has concerns that political issues will delay progress in this area. If these political issues can be resolved, SAC sees South Africa launching a

two meter resolution satellite in the next five to ten years. The momentum to launch these satellites is growing as the cost of U.S. and European remote sensing continues to rise. CSIR has a long-term goal to serve as a mission control site for all African owned satellites.

Geospatial Research and Applications

Numerous agencies and institutions are engaged in the application of geospatial science and technology at all levels of government. The academic community also engages in a wide range of activities--many linked to sustainable development in South Africa and neighboring states. South Africa contributed initial vegetation maps for southern Africa to the FAO Global Landcover Network, which classified the vegetation according to the common land cover classification system (LCCS). Eskom, the South African energy company, uses the Advanced Fire Information Service to monitor wildfires that threaten electricity transmission lines. CSIR has also conducted research to use remote sensing to identify likely mineral deposits for exploitation. The Agricultural Research Center (ARC) uses advanced technologies on par with any other developed nation. Data issues identified appear manageable as national funding becomes available. ARC seems well connected with other organizations within South Africa, though some additional connectivity with the Remote Sensing Centre might be of value.

Data Gaps, Requirements, and Coordination

The Office of the Surveyor General has been a prime mover in the Mapping Africa for Africa (MAFA) initiative. MAFA has thus far catalogued baseline data layers and gaps for most of Africa through a contract to EIS-Africa and the Africa Geo-Information Research Network. This initiative offers an excellent platform from which further regional collaboration may be launched.

The government has maintained an active role in the establishment of spatial data infrastructure nationally and regionally. The government is implementing the December 2007 Spatial Data Infrastructure Act. As part of this law, every city must prepare a spatial development plan, but most lack skilled staff with which to develop and implement such a plan. The CSIR's Meraka Institute has been playing a big role in promoting interoperability of spatial data among the various national entities. EIS-Africa, based in Pretoria, has also played a key facilitative role in this effort nationally, but particularly at the Africa-regional level. The State Information Technology Agency (SITA) has the mandate for ICT coordination across government. SITA is also responsible for supporting government regulations mandating exclusive use of open source software in all aspects of government operations.

Remote sensing data are important to the ARC activities and cost is a constant concern that is widely shared among university and government institutions. Innovative methods of obtaining important data at a reasonable cost have been developed, such as the airborne videography approach for acquiring important spectral band data when hyperspectral data are not available.

Geospatial Science and Technology (GST) Collaboration

There is a very limited supply of technically trained people in South Africa relative to the overall demand. Only Fort Hare has a remote sensing/GIS degree program, but several include remote sensing in geography and engineering curricula. Witwatersrand University faculty expressed a strong interest in expanding the existing GIS Laboratory and related GIS instruction and research. Currently, competing employment offers from the private sector and from international NGOs is complicating efforts to hire and retain qualified faculty for Witwatersrand University's GIS program. Expansion of existing collaborations and development of new relationships with U.S. institutions could help augment the needed core expertise in this area. Continuing to support the AfricaArray program, while reviewing its effectiveness at meeting its training and outreach mission, is another possible area for collaboration.

The South Africa Weather Service staff expressed the desire to host a U.S. sponsored fellow, such as an Embassy Science Fellow or Fulbright, who is an expert in geospatial data portals. Another need was expertise in air quality data, including quality assurance and control as well as managing data compatibility. There is also a desire for help from U.S. experts on nowcasting.

Summary Findings

Acquisition of sufficient remotely sensed data is a concern as is real time acquisition of hydrological and meteorological data. The difficulty of obtaining data from some agencies is often due to insufficient resources (human and capital) to acquire, process, and distribute data. Some scientists, including personnel from the Agriculture Research Council (ARC), expressed a desire for more frequent satellite imagery and coverage, were concerned over the loss of the full capability of Landsat ETM, and would like to see the Landsat follow-on mission take place with the same capability of the earlier versions of Landsat. In the meantime they are learning to use other satellite data.

Government scientists, engineers, and academics are frequently recruited away by the private sector, thus limiting continuity in government capabilities. Additionally, within the public geospatial community, public servants often lack the project management skills needed to design, negotiate, and sustain collaboration. As with other organizations in South Africa, and elsewhere throughout Africa, there is a need for people with the proper skill sets. Enhanced remote sensing skills were identified as being of particular importance.

The Satellite Application Center is struggling with the cost of archiving data on obsolete media, such as DLT tapes. Center staff also has difficulty providing students with costly archived imagery, but this may soon be effectively addressed through a new policy.

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Appendix 1: Team West Site Visits

Laboratoire de Télédétection Appliquée (LTA), Institut des Sciences de la Terre, Université Cheikh Anta Diop (UCAD), Senegal

Mission of the Organization

LTA was created in 2001 within the Institute of Earth Sciences of the Faculty of Sciences and Technologies at UCAD in Dakar. LTA's research mission is to provide: 1) practical and supervised remote sensing training (processing of satellite-based optical and radar data, multi-source, multi-temporal, and multi-sensor data fusion, image analyses and interpretation), and 2) applied research in the Earth Sciences (geological and structural mapping, mineral exploration, hydrogeology, and geo-hazards).

Key Personnel

Professor Souleye Wade

Geospatial Activities, Research, and Applications

LTA's research includes remote sensing applications on disaster management, dengue fever, mineral exploration, coastal zone radar mapping, flooding, and erosion. The research group's focus is to provide information driven by user needs that supports better decision making. Several students have written dissertations on the use of GIS and flood management in the St. Louis region of Senegal. The European Space Agency (ESA) also provided free data for a project remote sensing of water resources.

Current Collaboration Efforts

Both ESA and the French Ministry of Foreign Affairs provide LTA with funding, software and computers. Among domestic and international sponsors and donors are USAID (which supported their Natural Resources Based Agricultural Research Project); the French Research Institute for Development (IRD); the French Ministry of Foreign Affairs (Coopération pour la Recherche Universitaire et Scientifique Project); World Bank (Higher Education Enhancement Project); and the Remote Sensing Network of Francophone Universities (Francophone University Agency, AUF).

The laboratory staff consists of 11 "researchers" and nine "Ph.D.-level researchers" with advanced degrees in geology, hydrogeology, geomorphology, climatology, soil sciences, remote sensing and GIS. These researchers have associations with the following institutions: University of Dakar's Geology Department, Centre de Suivi Écologique (CSE) in Dakar, Office of Coordination for Humanitarian Affairs (OCHA) West Africa Regional Office, SAED, Remote Sensing Network of Francophone Universities (AUF), European Space Agency (ESA), Pasteur Institute of Dakar, Global Change System for Analysis, Research and Training (START), and the Canadian International Development Research Centre (IDRC).

Ongoing research includes the following titles: "Remote Sensing and GIS for Disaster Management: Studies of Floods of the Senegal River and Floods in the City of Saint Louis"; "Studies of the Water Resources, Floods and Environment of Saint Louis (Senegal) and Douala (Cameroon)"; "TIGER Project 2975-Remote Sensing of Senegal's Environment and Water Resources"; "Fresh and Waste Waters in the Urbanized Regions around Dakar, Senegal"; "Setting the Benchmark--What do we know? What is our future? "A Science Review and Synthesis Workshop on the Long-term Impacts of Environmental Change in West Africa"; "GIS and Remote Sensing Applications in the Study of the Environmental Conditions that Support the Emergence of Dengue-2 Virus inside the Area of Kedougou (Eastern Senegal)".

LTA has collaborated with international space programs: Committee for Earth Observing Satellites (CEOS), United Nation's Office for Outer Space Affairs, and European Spatial Research Institute (ESRIN) of ESA.

Capacity and Ability to Influence Decision-making

LTA's research efforts are user-driven and produced to help policy makers make better decisions. Their work focuses on applying geospatial technologies to problems that directly affect development efforts in Senegal, including flooding, dengue fever, water resources, and mineral exploration. Former students who trained and completed their dissertations at the lab have moved on to positions in decision-making organizations such as the UN Office for the Coordination of Humanitarian Affairs. LTA is in a position to both directly and indirectly influence policy through the production of geospatial information and products as well as the training of future talent.

Summary Findings

Prof. Wade's laboratory offers a key center of excellence in Senegal that can have a long term impact in Senegal and the West African region through training, research and education. Supporting his efforts in LTA could have significant impacts in improving capacity in geospatial science and technology. He currently serves as a Board Member of the Remote Sensing Network of Francophone Universities, representing Sub-Saharan Africa and is also a member of the CEOS African Advisory Group. He has an excellent technical background and has good knowledge of international remote sensing networks. However, he is working with limited financial and institutional support. United States investment in this laboratory could have a long term impact on improving Senegal's science and technology capacity.

Laboratoire d'Enseignement et de Recherche en Géomatique (LERG), Université Cheikh Anta Diop du Sénégal (UCAD), Senegal

Mission of the Organization

LERG focuses on training, education, and research. LERG is developing a GIS master's degree program, intended mainly to provide GIS training for other departmental programs (geography, geology), entirely at master's and doctoral level. LERG is strong in training and research and supports both the Environmental Science Institute and Senegalese Agricultural Institute. LERG trains some students from the Earth Sciences (Applied Geology) Institute but the two institutions have no formal relationship.

Key Personnel

Professor Tahirou Diaw

Geospatial Activities, Research, and Applications

Prof. Diaw leads a graduate program which consists of four faculty members; currently three Ph. D.s, and ten Master's Degree students in house. Since 2001, the program has produced 18 Ph. D's in geography, geology, and physics.

LERG is impressively strong in certain applications including bush fires, carbon sequestration, agriculture, climate change, erosion, and flooding impacts on settlements. Work on mangrove ecology, erosion, carbon sequestration, and bush fires is done in collaboration with the University of Maryland.

LERG faculty feel hamstrung at present by the "French System" in which graduate students work independently without taking formal courses. They want to switch to the "British System" so they can teach formal courses at the Ph. D. level. This is especially important for teaching GIS.

Their current software suite includes ENVI, AR Mapper, IDRISI, ArcView 3.2, and ArcGIS 9.X. In addition, the faculty wants ERDAS (Earth Resource Data Analysis System) software but cannot afford it. They are involved in the Great Green Wall African Initiative on afforestation/deforestation and have published related work in the *African Journal of Environmental Science and Technology*, and are doing work on monitoring urban sprawl over time. Because of the importance of fishing as Senegal's third highest source of revenue generation, LERG also routinely conducts real time modeling of sea surface temperature to produce indicators of fish concentration.

Current Collaboration Efforts

LERG works closely with several UCAD academic departments, providing GIS training and research assistance to graduate students engaged in thesis and dissertation research. Principal departments include geography, geology, and physics. They want to build partnerships with other institutes for training of geomatics practitioners. Current partnerships include Michigan State University, the University of Maryland, Institut Géographique National of Senegal, and UCAD's Department of Urban Planning.

LERG is part of the West African Remote Sensing Network (Burkina Faso, Mauritania, Côte d'Ivoire, Benin, Guinea, Mali, and Ghana). Jointly, these countries produce an "Active Fire" product in collaboration, led by David Schul of Michigan State University.

Analytical, Data, Technical, and Infrastructure Issues

LERG's highest priority is training trainers with the intention of becoming self sufficient in terms of GIS capability in country. They serve as a university-wide GIS laboratory for UCAD with specialties in social science, remote sensing, and GIS

Capacity and Ability to Influence Decision-making

LERG is not directly involved in decision support on policy matters. LERG monitoring systems and data do support resource management in fire control and fishing activities. Currently they are reorganizing the curriculum to include a masters in Remote Sensing and GIS. Most Senegalese experts are trained elsewhere, but LERG wants to establish a new model by training experts in house, supported by public

institutions. The National Geomatics Plan, a 1996 Canadian-funded interagency endeavor, has succeeded in reorienting the Senegalese IT Agency (ADIE), with its own Geographical Center.

Summary Findings

The francophone countries of West Africa already are engaged in some collaboration with one another. There is a substantial potential for supporting ongoing collaborations by working with one or more of the institutions within a particular collaboration. For instance, LERG needs assistance in curriculum development as it switches its program from the French system to the British system.

Centre de Suivi Écologique (CSE), Senegal

Mission of the Organization

CSE's mission is 1) to support the planning and management process of natural resources in Senegal and in West Africa; 2) to work with partners in Senegal's development; to formulate and implement projects in ecological monitoring and related fields; and 3) to support private sector development through training and partnerships and technology transfer through training.

Key Personnel

Amadou Moctar Niang, Director

Assize Touré, Technical Assistant Director

Geospatial Activities, Research, and Applications

CSE is a key environmental monitoring institution, with a considerable repository of data and information on Senegal's natural resources and environment and a source of data for the broader Sahel region. CSE's strategy is to use state-of-the-art remote sensing and geospatial tools to produce a wide spectrum of geographic products that respond to needs of users at local, national, and regional levels. CSE authors a biennial report on the State of the Environment. This report is quite broad in scope, addressing many sectors of the environment and ties to economic activity.

CSE regularly uses a variety of sources for remote sensed data from satellite systems including NOAA Advanced Very High Resolution Radiometer (AVHRR), Landsat, Satellite Pour l'Observation de la Terre (SPOT), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), IKONOS, and Corona. CSE has also conducted aerial surveys for livestock inventory, rangeland assessments, and forest mapping. CSE staff are engaged in numerous themes of activities including baseline mapping of natural resources, infrastructure mapping, land use and land cover mapping and monitoring, urban studies including pollution and flooding, soil potential mapping, assessment of degraded lands, time-series studies, fire mapping, monitoring agricultural production, and herbaceous biomass monitoring.

Current Collaboration Efforts

CSE has a long history of collaboration with local, national, regional and international partners. International collaboration began with core funding for CSE's monitoring and research activities through the U.N. Environment Program and the U.N. Food and Agriculture Program (FAO). Another important historical partner has been the University of Denmark, beginning in 1986. From 1994 to 1999, CSE collaborated with the U.S. Geological Survey-EROS Data Center (USGS-EDC) in a project to monitor long term changes in Senegal's natural resources. This was followed by joint research activities with EROS in carbon sequestration in the soils and vegetation, including modeling future sequestration under different land management practices and prevailing climate change scenarios.

Current collaboration includes work with the European Space Agency to monitor bush fires in near-real time. It is also working with the USAID to support the Agricultural and Natural Resources Management Project (2002-2008) by providing image-maps for sustainable use of forest resources by local communities. CSE is also collaborating with FAO on a project to assess land degradation using innovative remote sensing techniques.

CSE has numerous ongoing activities with the government, including development of end-of-season biomass maps that help assess rangeland forage for better management in the livestock sector. One of the most significant activities was a 1998 forum organized by CSE to help develop a National Geomatics Plan. Since 2000, the government's interest in geospatial data has increased and support is growing. The plan's main government point of contact is Senegal's Agence de L'Informatique de l'État Secrétariat du Directeur Général. This organization reports to Senegal's Office of the President.

GDEST team member Gray Tappan, from USGS, has been a key U.S. contact and collaborator with CSE, and has conducted over two decades of research in the region that has led to a number of articles in scientific publications on dry lands and the Sahel.

Analytical, Data, Technical, and Infrastructure Issues

CSE has a broad level of expertise in research and applications of remote sensing and geospatial technologies. CSE's ongoing challenges include the need to keep professional and technical staff current in rapidly evolving technologies. Collaborative projects that would help CSE staff keep abreast of technical developments in geospatial science. Another challenge is in implementing CSE's goal to transfer technology and training to local institutions and users across Senegal, i.e. to decentralize the use of geospatial tools and data. Local level institutions are approaching CSE with requests for greater amounts of data for local-level decision support and disaster management.

An ongoing issue with regard to data is the increased need for high resolution image data (e.g. from commercial U.S. satellite systems). There is much demand to map natural resources at larger scales, working with local level decision-makers, and rural development projects. CSE also requested access to the latest data on vegetation to update existing land cover reports.

CSE staff is interested in broadening their monitoring activities to include coastal erosion, urban sprawl, and land degradation. The staff also expressed an interest in greater collaboration with U.S. and international partners, workshops, conferences and access to two to three month training courses. They even used the words, "we want to reduce the isolation of CSE." Expanded international cooperation could assist them in taking their fire monitoring activities from mere detection to modeling and fire prevention programs. One of the best ways CSE has gained data, and in particular, experience and new geospatial tools, is through specific projects with European and North American partners.

Capacity and Ability to Influence Decision-making

CSE is the technical arm of the Ministry of Environment. It has semi-autonomous status that gives it flexibility to work with external partners under repay contracts. CSE enjoys a strong reputation in the government for its ability to produce geographic products that address key issues in development and natural hazards. The CSE Director is the environmental advisor to the Prime Minister as well as the Minister of Environment. CSE's reports and publications have been widely used over the years in Senegal's environmental planning policy arena and have also highly influenced thinking in formulating a National Geomatics Plan, which exists in draft form but has not been formally adopted. CSE is eager to see the final Plan and its implementation by the government.

On a practical level, CSE continues to carry out monitoring efforts for the country, including fire ecology and rainy season biomass productivity. Their products are regularly used for decision-making in forestry and livestock sectors.

Summary Findings

CSE could be considered one of the highest priority institutions for continued dialogue under GDEST Africa, and for formulating specific projects with American counterparts in the use of geospatial tools for environmental mapping and monitoring. For example, CSE has a long history with the USGS EROS Data Center, and building on these ties would be mutually beneficial for scientists on both sides of the Atlantic. This work has implications beyond Senegal, including West Africa, the Sahel and the continent of Africa. CSE staff share a common interest in applying geospatial tools in research and applications in such fields as long-term ecological monitoring, climate change impact, carbon sequestration, and land productivity.

Direction des Travaux Géographiques et Cartographiques (DTGC), Senegal

Mission of the Organization

The DTGC is the national mapping organization of Senegal. The DTGC's mission is to implement the mapping, collection, and processing of geographic data.

Key Personnel

Youssou Ndong, Director of the Cartographic Office.

Geospatial Activities, Research, and Applications

The DTGC is in charge of national mapping efforts for all of Senegal. DTGC uses many different geospatial software packages, including Geoview, a French product; ArcGIS; Geoconcept used in conjunction with Freehand; Photoshop; and MAPublisher. DTGC projects are produced on paper and stored digitally as shape files in ArcGIS. All products currently produced for the government are supported by WGS-84.

Current Collaboration Efforts

The DTGC in collaboration with the European Union (EU) is updating all of Senegal at a scale of 1:200,000 using Spot 5 imagery to collect all new digital data. In 2004, DTGC produced the first 11 sheets covering eastern Senegal to support the mining efforts that were under way in the area. In 2006, DTGC completed an additional ten sheets covering central Senegal.

Analytical, Data, Technical, and Infrastructure Issues

All investments for DTGC projects come from government grants based on political decisions. DTGC has ambitious plans for the future—posting all DTGC products on the internet, producing thematic and tourist maps of Senegal, rural and urban maps of areas of special interest, navigational maps with the help of GPS in Dakar, as well as digital data over the entire country at a scale of 1:50,000 scale or larger.

Capacity and Ability to Influence Decision-making

All decisions on DTGC direction are based on how much those decisions can influence GIS government support. Harmonizing and standardizing data for the benefit of the nation is an important goal. The DTGC seems to have a good plan, but they will need the backing of the government to be successful.

Summary Findings

None provided.

Agence de l'Informatique De l'État (ADIE), Senegal

Mission of the Organization

The ADIE's mission is 1) to modernize the country through new technology, which includes the creation of a coherent information technology system for the state, and 2) to develop the communication and information sectors. The agency is in charge of the information infrastructure systems of the country and coordinates between different parts of the government that collect and maintain different types of data.

Key Personnel

Mouhamed Tidiane Seck, Director General

Geospatial Activities, Research, and Applications

The agency is in charge of the Plan National Géomatique (National Geomatics Plan), which will place all of the geospatial information of the country under the coordination of ADIE. Inspired by a similar plan in Tunisia, the plan aims to combat interoperability problems between information databases used by different parts of the government. The Canadian International Development Agency (CIDA) has been assisting with its development. ADIE has met with other agencies and organizations such as DTGC, CSE, the Cadastral Survey, the National Statistics Institute, and their Internal Revenue Service and plan to have a meeting with the Prime Minister, who is supportive of the initiative, to begin the process of approving the national plan.

The ADIE has about 50 employees (20 engineers, 15 technicians, and 15 administrative and financial staff) deployed in support of a similar continent-wide plan to harmonize national policies. Senegal is also working with telecommunications companies to design a plan to cover the country with fiber optic cables and is using ESRI software to decide the most efficient and best way to accomplish this task.

Current Collaboration Efforts

Flooding is a major issue in Senegal near Saint Louis and ADIE is collaborating with CSE and Université Cheikh Anta Diop (UCAD) to do research in this area. They are also collaborating with UCAD to begin a GIS training program.

Analytical, Data, Technical, and Infrastructure Issues

ADIE staff desire to replace manually produced black-and-white paper maps with more costly digital maps. . ADIE's goal is to place digital maps in a single, central database for interagency distribution. The digital effort is expected to reduce duplication and costs and increase efficiency and cooperation within the government. The team noted that the U.S. Government may potentially be interested in joint production agreements with ADIE and asked for a list of priorities from which to initiate a joint pilot project with the U.S. Government.

Capacity and Ability to Influence Decision-making

ADIE is the lead on the National Geomatics Plan on geospatial information in Senegal. The plan's implementation should lead to greater accessibility of data of all types by decision-makers throughout the government. The agency will be crucial to ensuring that data is collected, archived, and made available to geospatial researchers throughout Senegal for furthering the region's sustainable development.

Summary Findings

None provided.

Roundtable Discussion, Senegal

Roundtable Purpose

A round table was held to identify the overall state of geospatial research and needs in Senegal.

Key Participants

GDEST Team West

Mr. Aliou Dia, GIS officer, UN-OCHA (Office for the Coordination of Humanitarian Affairs)

Senegalese users of geospatial data from the private, public, non-governmental and academic sectors

Summary Findings

- *High resolution imagery for mapping at larger scales:* One of the big obstacles is the high cost of recent commercial satellite imagery to support various time-sensitive applications. Most public institutions can obtain older imagery at a low cost or gratis.
- *Bridging the private-public sector gap:* Private sector researchers have available specialized geospatial data which should be freely shared with public sector counterparts.
- *There is a need for more sophisticated and mature use of geospatial data and analysis:* Training is needed in modeling to go beyond satellite remote sensing for mapping and monitoring natural resources.
- *Dataset availability:* Emergency management usually requires several fundamental or core geographic data types, such as roads, population, climate and land cover. Senegalese partners were unaware of core datasets available globally at a resolution of 1 km--the LandScan human population data layer.
- *Driving factors behind environmental change:* Senegalese partners were generally unaware of the role of local and national economic and environmental policies.
- *Dynamic mapping:* Geospatial analysts need time-series imagery, including historical aerial photographs and Landsat imagery, for researching land degradation and desertification to show environmental changes over time
- *Monitoring carbon sequestration:* Researchers seek to examine changes in land resources, especially the vegetation cover, with carbon stocks in the vegetation and soils. Ultimately, they seek projects with northern industries to sequester carbon and obtain credits of their emissions under the Kyoto protocol framework.
- *Continuing GDEST Dialog:* One of the most significant outcomes of the roundtable discussion was the suggestion to create a small working group of Senegalese geospatial stakeholders to continue the dialogue between the GDEST delegation and the Senegalese stakeholders in geospatial information.
- *Implementing the Senegalese National Geomatic Plan:* The plan calls for national cartographic and geospatial standards. The plan also provided for digitization of existing 1:200,000 topographic maps. The remaining challenge is to identify constraints in the finalization of the design and implementation of the plan.
- *Supporting bilateral projects:* To move forward geosciences in Senegal, researchers have proposed pilot project—most of which require high resolution image data and costly datasets. One difficulty is defining a concrete project that is both useful and constructive in addressing a particular development problem in Senegal—an activity that would allow the U.S. to provide expertise or useful remote sensing data that would be applied to such a specific application. Continued dialogue with the geospatial working group will be instrumental in defining appropriate project development needs and scope, and linking possible Senegalese participants with points of contact in the State Department and its partners.
- *Regional and global dialog:* DGTC colleagues mentioned a desire for them to participate and contribute to regional and global processes for SDI development such as CODI-GEO, possibly working with RECTAS at the regional level, and at the global level, IGOS, CEOS and GEO.
- *Improving governance:* The U.S. Government considers the promotion of good governance one of its highest priorities and the GDEST program recognizes that improving the access, use and analysis of geospatial data is a key element in helping to promote good governance through transparency, improved communication, and informed decision-making. In essence, through this Global Dialogue on Emerging Science and Technology, the team hopes to promote geography and geographic tools to promote governance.
- *Next steps:* Identify project applications requiring high resolution commercial satellite imagery. Team members may be able to help provide access to these detailed data on a project basis, rather than by responding to a general, blanket request for imagery. The team hopes dialogue is the start of a follow-on exchange leading to sharing of data, knowledge, and specific projects collaboration.

Institut Géographique du Burkina Faso (IGB), Burkina Faso

Mission of the Organization

The mission of the IGB is to oversee all aspects of mapping for Burkina Faso. IGB implements the government's National Geographic Plan to produce a base map over the entire country.

Key Personnel

Mr. Abdoulaye Belem, Director Technique

Geospatial Activities, Research, and Applications

Currently the IGB employs over 70 employees, 35 of which are professionals. Personnel at the institute have taken advanced geospatial training in places like the Netherlands, Japan, France and Nigeria. IGB researchers are working on updating the 1:200,000 scale base map of Burkina Faso. Replacing paper maps with digital maps is in the works. IGB is also producing a rural space management map using Landsat data with a 40 meter contour spacing. IGB is nearly 30 percent finished with mapping the entire country at a scale of 1:50,000 scale.

Current Collaboration Efforts

IGB is experiencing more demand than ever by different government organizations on forestry, water management, and agriculture issues. IGB has collaborative projects with state and local governments. Some of the staff teach at the University of Ouagadougou and have held joint workshops to exchange GIS technical expertise.

Analytical, Data, Technical, and Infrastructure Issues

Although the institute uses some of the latest software, including ESRI products, they are still behind in the standardization and collection of geospatial information. Their 1:200,000 scale base map is referenced to old topological maps rather than the more universal WGS-84. They have used GeoEye and QuickBird images for some of their 1:50,000 scale topological maps, but they still need additional software and hardware to truly be able to reach their mission of a country-wide universal and harmonized database.

Capacity and Ability to Influence Decision-making

IGB is the national mapping agency for Burkina Faso and their work is extremely important to other government agencies. However, higher level decision makers determine projects funding and IGB does not always receive the necessary support required to reach their objectives. It is essential that they convince policy markers of the importance of their work so that they receive the funds needed to purchase the software and hardware needed to complete their mission.

Summary Findings

None provided.

Centre de Système d'Information Géographique et Télédétection–Adjaratou (Centre SIGET – Adjaratou), Burkina Faso

Mission

SIGET's mission is to provide training, mapping, and analysis services in cartography, satellite image processing, GPS, GIS development, and database development. SIGET is a private organization located in Ouagadougou, Burkina Faso that provides regional training and performs contract work in GIS and remote sensing applications. It is also a regional distributor of ESRI products.

Key Personnel

Mr. Patrice Sanou, Director General

He is also a board member of EIS-Africa, works with UN Office of Outer Space Affairs (UNOOSA), UNECA, and was secretary of AfricaGIS 2007. Mr. Sanou received his M.S. from South Dakota State University.

Geospatial Activities, Research, and Applications

SIGET staff includes 17 permanent employees and part-time individuals, including university faculty. SIGET works on applications that include disaster management, natural resource management, infrastructure, and health. As an Institute, SIGET offers a B.A. degree in space technology and has applied for approval to offer a M.S. degree in geospatial technologies in monitoring and analysis, disaster management, health care, education, and environment.

Current Collaboration Efforts

SIGET collaborates with the University of Ouagadougou's Department of Geography in teaching and provides opportunities for interns. Other partners include USGS EROS Data Center, UNOOSA, UNECA, EIS-Africa, UNEP/FAO, ESRI, SAMBUS Co. Ltd. Cetel International, Cetel-BF, Cetel-Babon, Cetel-Niger, Cetel-Chad. University partners include S. Dakota State, Brown University, University of Iowa, Washington State University, and University of Poitiers (France).

Analytical, Data, Technical, and Infrastructure Issues

Current training facilities include a laboratory setting with about 30 computer workstations equipped with standard GIS and remote sensing software (ArcView, ERDAS, ILWIS, WinChips, MapInfo, IDRISI, GeoVIS), stereoscopes, and GPS units. As a reseller of ESRI products, SIGET has adequate licenses for ESRI products, but must pay license fees for other software. Data acquisition and handling were not indicated as major problems as data are obtained on a project basis, for which funding is provided.

The director has an ambitious growth plan, particularly for training of technicians. Availability of partnerships was indicated as a greater need than availability of funds. Currently located in temporary headquarters, SIGET has a land grant to build a larger facility near the Ministry of Environment to increase potential for training, but must secure separate funding for the building.

Capacity and Ability to Influence Decision-making

SIGET appears to be respected in the region and could be influential in both government decision-making and defining the direction of geospatial education at the national level. Director General Sanou's commitment to applications of geospatial capabilities drives SIGET's ability to influence. The Director also stressed the contribution to good governance in a developing country provided by the transparency of geospatial technologies.

Summary Findings

None provided.

Ministère de l'Environnement et de l'Eau, Burkina Faso

Key Personnel

Laurent Sedogo, Minister of the Environment and Water.

Georges Yameogo, Director Institut de l'Environnement et de Recherches Agricoles (INERA), Burkina Faso.

Minister Sedogo, who holds a Ph.D. in geography, became the Minister of Agriculture shortly after the GDEST visit.

Current Collaboration Efforts

The minister expressed strong support of the GDEST mission and offered to assist in any way he could. He brought attention to an initiative by Microsoft on information and communication technologies called the African ICT Best Practices Forum that was held in Ouagadougou April 21-23, 2008. The delegation was asked if it might send a representative to attend. Paul Bartel from the delegation accepted the invitation and attended the conference.

NERA and the USGS Center for Earth Resources Observation and Science have been collaborating on an effort to map trends in land use and land cover in Burkina Faso. Results from this effort are used in environmental planning and natural resource management.

Summary Findings

None provided.

Université de Ouagadougou, Département de Géographie, Burkina Faso

Mission of the Organization

The University has recently initiated a master's program in Geography, which focuses on training professionals for positions in government and the private sector.

Key Personnel

Francois de Charles Ouedraogo: Geography of Health and Food Security

Tanga Pierre Zoungrana: Agricultural hydrology, including irrigation and health

Honore Some: Land use planning, remote sensing

Yameogo Lassane: Hydrological infrastructure in agriculture, GIS applications.

The Department currently has several faculty members with specialties in various fields of physical geography

Geospatial Activities, Research, and Applications

The university teaches basic courses in GIS and remote sensing to provide students with skills for applications in water management, land use, and environmental applications.

Current Collaboration Efforts

Faculty members work with SIGET and lecturers from both programs teach and supervise research interchangeably. The department works closely with professional partners in the government and the private sector to determine their requirements, and attempts to incorporate these into the curriculum. In turn, partners provide internships, both to support students and provide opportunities for future employment. Currently, 14 students are enrolled in the program, 9 of which are employed by partners.

Analytical, Data, Technical, and Infrastructure Issues

Infrastructure is a major challenge at the University of Ouagadougou. The GIS laboratory was equipped with a limited number of old computers in an environment with limited uninterrupted power. Two to three students shared each computer. Software licenses for ERDAS and ArcGIS were installed, but out of date, and access to the internet was extremely slow and unreliable.

Capacity and Ability to Influence Decision-making

The Department of Geography is filling a need in graduate public education in applied geographical sciences. The faculty is closely linked to the government and private sector in its attempts to advance technical capability. It is difficult to evaluate the long term potential for influencing decision making, given that the program is new and resources are so limited. In addition to training students, the department is planning a new library and intends to publish a periodical.

Summary Findings

None provided.

L’Institut international d’Ingénierie de l’Eau et de l’Environnement (2iE), Burkina Faso

Mission of the Organization

The International Institute for Water and Environmental Engineering (2ie) is a higher education and research institution based in Ouagadougou, Burkina Faso. 2iE focuses on water, environment, energy and global change.

Key Personnel

Paul Ginies, General Manager

Philippe Girard, Scientific Advisor

Corentin Some, Responsible for Service SIG-E program

Geospatial Activities, Research, and Applications

EIER-ETSHER Group, and its 2iE follow-up, is the center of excellence in science and technology of the West African Economic and Monetary Union (WAEMU). The Council of Ministers for EIER-ETSHER Group, decided to reconfigure 2iE’s approach and agenda In June 2006. As a result, 2iE gained greater private sector participation. The current campus has classrooms, amphitheatres, laboratories, experimental sites for more than 320 students, and will soon open a second campus. The skilled teaching staff comes from more than 12 nations, a majority from West and Central Africa.

2iE has a geomatics program called Service SIG-e, which conducts research and applications on water, environment, energy and infrastructure. Last year, 2iE held more than 20 interdisciplinary geospatial sessions, serving more than 300 students from Burkina Faso, Niger, Benin, Togo, and Senegal. The current campus offers over 60 computers with good (one gigabyte per second switch) Internet connectivity, and access to the latest ESRI and ERDAS software.

Current Collaboration Efforts

EIER-ETSHER has many scientific and financial partners: the Polytechnic Federal School (EPFL) of Lausanne, Switzerland, France’s Agricultural Research Centre for International Development (CIRAD), Development Research Institute (IRD), World Bank, and African Development Bank. They also receive funding annually from the French Foreign Ministry. The budget also includes in-kind contributions from the Sahelian country members, such as the Burkina Faso contribution of land.

Capacity and Ability to Influence Decision-making

Burkina’s President, Blaise Compaore’s active engagement in this institution makes this program a priority partner for U.S. engagement, as it is likely to have a large and long-term impact on the country’s science and technology capacity. 2iE is also leveraging considerable resources from European donors. It has a 35 year record of work and seems to be well positioned to have medium and long-term impact on Burkina and West Africa.

Summary Findings

None provided.

USAID Famine Early Warning System Network (FEWS NET), Burkina Faso

Mission of the Organization

FEWS NET's mission is to provide early warning information to decision-makers in the U.S. Government on food security conditions and to identify populations at-risk of famine in sub-Saharan Africa, and in select countries in southern Asia and Central America.

Key Personnel

Salif Sow, FEWS NET/Burkina Regional Field Representative

Geospatial Activities, Research, and Applications

The FEWS NET office in Burkina, staffed by Salif Sow, is responsible for assessing food production, food security, and identifying populations at risk of food shortages in Burkina. The FEWS NET Burkina office provides weekly summaries to FEWS NET headquarters in Washington. It also shares this information freely with CILSS (Comité Inters-Etats de Lutte Contre la Sécheresse au Sahel) and AGRHYMET. FEWS NET Burkina is expanding its geographical mandate to begin looking at food security problems (and other hazards that place human populations at-risk) in non-Sahelian countries, including the coastal countries of Benin, Togo,

Remote sensing plays a vital role in the daily business of monitoring food production conditions across Burkina. The key tools are NOAA-AVHRR Normalized Difference Vegetation Index Images (NDVI), which are summarized into 10-day composites, and Rainfall Estimation (RFE) images, computed from models based on cold cloud duration, using Meteosat data.

Another key source of data is market price data of basic food commodities such as maize, sorghum, millet and rice. Other data monitored by FEWS NET include nutritional intake data and other data from rural health centers. By using a convergence of evidence approach, the FEWS NET analysts identify specific areas and populations of the country that are at risk of food shortfalls or other threats to human livelihood.

Current Collaboration Efforts

FEWS NET collaborates closely with West African regional and national institutions. Among these are CILSS, ECOWAS (Economic Community of West African States), AGRHYMET, local NGOs, and the national early warning units within the host countries. FEWS NET relies heavily on a consortium of U.S. partner agencies for data and analysis, including NOAA, NASA, USGS, and USAID. Its primary client is USAID.

Capacity and Ability to Influence Decision-making

Information and analyses produced by FEWS NET directly helps decision-makers act to mitigate food insecurity. While much of the information is digested and acted upon at USAID in Washington, FEWS NET Burkina regularly shares its information and reports with early warning and monitoring units in the Sahel. Regional organizations such as CILSS and its technical monitoring center at AGRHYMET incorporate FEWS NET information from FEWS NET field offices in their own assessments and decision-making process, leading to better response and mitigation efforts.

Summary Findings

The GDEST team made a courtesy call to FEWS NET to better understand how the project uses geospatial data and tools to monitor food security in the region. The visit served to give the team insights into the challenges of applying remote sensing and other technologies to monitoring crop production, rainfall, and other key variables in the food production equation. The visit was primarily for informational purposes, rather than for formulating future cooperative projects with FEWS NET.

Centre Régional de Formation et d'Application en Agro météorologie, Hydrologie et Météorologie (AGRHYMET), Niger

Mission of the Organization

The mandate of AGRHYMET is "to seek to assure food security and to combat the effects of drought and desertification for a new ecological balance in the Sahel." The mandate of the AGRHYMET Regional Center includes three main components: (1) data collection, dissemination on food security, natural resources management, water management, and desertification control in the Sahel; (2) development of decision support tools for the region, and (3) technical capacity through training for member Sahelian countries in the fields of climatology, agro-meteorology, hydrology, crop protection, geospatial analysis and remote sensing.

Key Personnel

Mohamed Yahya Ould Mohamed Mahmoud, Director General
 Brahma Kone, Chief, Department of Technical Support
 Dr. Seydou B. Traore, Agro-meteorologist, Chief, Scientific Coordination Unit
 Faustin Gnoumou, Agro-meteorologist, Chief, Dept. of Education and Research
 Dr. Brahma Sidibe, Chief, Dept. Information and Research
 M.Henri Songoti, Chief, Database Division

Geospatial Activities, Research, and Applications

The AGRHYMET Regional Center was created in 1974 as the technical institute of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS). It is an interstate body with a legal status and financial autonomy based in Niamey, Niger. Currently the facility has six laboratories and 140 students. AGRHYMET has an extensive list of projects and a long record of capacity building across the Sahel, including short and long term workshops and courses. From 1974-2006, over 710 technicians and 135 engineers, mostly from CILSS countries and employed mainly by ministries, development projects and non-governmental organizations have received training from AGRHYMET.

Current Collaboration Efforts

AGRHYMET began as a NOAA supported activity to download and process meteorological data. Today, it has a broad spectrum of partnerships and receives financial assistance from the United States, France, Canada, Denmark, and the European Union. The list of partners includes the UN Food and Agriculture Organization, the World Food Program, and FEWS NET.

Analytical, Data, Technical, and Infrastructure Issues

AGRHYMET requires near real-time synoptic image data for monitoring vegetation production across the region, particularly during the growing season. It has relied on NOAA-AVHRR data since 1989 to accomplish this. However, with sensor drift and other technical problems associated with NOAA-AVHRR, AGRHYMET has investigated the use of MODIS image data from USGS EROS. With severe Internet bandwidth limitations, AGRHYMET staff is unable to download the large image files. Data streaming of MODIS and other image data is a major issue. For the same reason, AGRHYMET cannot use the Internet to offer its image products to users across the West Africa region. Downloading images and map products from AGRHYMET is an on-going problem. AGRHYMET would welcome assistance with these issues.

Capacity and Ability to Influence Decision-making

AGRHYMET Regional Center is a critical node of regional geographic information for decision-making (including early warning) in food security, desertification control, natural resources management and environmental monitoring in the Sahel. Beyond CILSS and its member states, the audience of AGRHYMET includes international and regional organizations such as the Food and Agriculture Organization, United Nations organizations working on food security, Economic Community of West African States (ECOWAS), West African Economic and Monetary Union (UEMOA), and the Central African Economic and Monetary Community (CEMAC). These organizations use AGRHYMET's products in their decision making.

AGRHYMET is officially the early warning tool of the CILSS. The institution has a critical mass of experts and state of the art technologies that give it an absolute authority to provide technical advice on questions

related to food security, desertification, natural resources and environment. It is clearly in a critical position to influence and inform policy makers across the Sahel. The United States could look for opportunities to raise the visibility of AGRHYMET's work to governments in the region.

Summary Findings

None provided.

Centre Regional d'Enseignement Spécialisé en Agriculture (CRESA), Université Abdou Moumouni, Niger

Mission of the Organization

CRESA's mission is to provide expertise and programs in environmental protection and improvement of farming systems.

Key Personnel

Dr. Adama Toudou, Director, CRESA, a specialized regional agricultural training center in within the Faculty of Agronomy

Dr. Yadjé Guero, Dean, Soil Science Department

Dr. Larwanou Mahamane, ecologist

Dr. Mahamadou Harouna, geodesist responsible for course development and remote sensing laboratories

Dr. Mahamane Larwanou, forest ecologist who has collaborated with USGS in use of remote sensing for monitoring land resource changes over the past four decades.

Geospatial Activities, Research, and Applications

Established in 1984, the university has about 10,000 students with a Department of Agronomy that contains roughly 300 students and 20 faculty members. The faculty's countries of origin are spread across the continent, with advanced degrees from institutions in Africa, the United States, and Europe. CRESA provides specialized training for university faculty and graduate students from five of the seven departments in the Faculty of Sciences, namely the departments of sociology, economics, animal production, plant science, soil science, and the department of water, forest resources and rural engineering. The university, through its Geography Department, offers undergraduate students general courses in mapping and topography, and geodesy plus an introductory course on remote sensing, with the lower level courses focusing on interpretation and use of aerial photography. At the graduate level, the department offers digital remote sensing with an introduction to satellite systems, and GIS. The Geography Department has basic GIS and remote sensing capability while other departments like Geology have no such capability. The graduate level course in remote sensing is a cross-cutting course attracting students from various majors. The university is transitioning from the French higher education system to the Anglo system used in Britain and the United States. This is a trend occurring in other West African universities as well. One advantage of the British-US system is that Ph.D. candidates are required to continue taking specialized courses, including GIS.

CRESA is in the process of creating a new lab which will house their image processing system. They have purchased computer hardware, and they will install ERDAS Imagine image processing software (also already purchased). The university has helped CRESA with funding for purchasing this equipment. It considers CRESA as one of a number of centers of excellence, allowing CRESA to benefit from university subsidies.

CRESA also works closely with other university faculties, helping to train teachers and students in engineering. CRESA offers general courses in agronomy as well as tailored refreshment courses for trainers, and specialized courses in animal production, plant science, water resources and forestry. The range of current CRESA activities includes a major project looking at production systems in the Niger River valley, soil investigations, livestock production systems, studies of degraded landscapes and their rehabilitation, and wind erosion.

Current Collaboration Efforts

CRESA also serves as an outreach institution, interfacing with the government ministries, non-governmental organizations, and foreign partners. Early on, CRESA received the full support of CILSS (Inter-governmental Committee to Combat Drought in the Sahel) which broadened CRESA's mandate to become a regional center specializing in agricultural research and training. CRESA received trainees from all CILSS member countries, as well as coastal countries outside the CILSS region. Agricultural production and environmental management remain the core areas of research and applications. Later, CRESA also embraced the fields of agro-pastoralism and agroforestry.

CRESA and the AGRHYMET Regional Center cooperate in several ways. Both centers belong to a Niger-based consortium of research institutions that includes African Centre of Meteorological Application for Development (ACMAD), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Institut de Recherche pour le Développement (IRD), and others. AGRHYMET's focus is more on agro-meteorology, near real-time monitoring of crop and forage conditions, and food security, in contrast to CRESA's applied research focus. CRESA sends some of its students to AGRHYMET for specialized training as needed.

Since 2000, CRESA has worked with U.S. partners, particularly with USGS/EROS. This research has concentrated on studies to assess the impact of private and public investments in natural resource management on food security, rural poverty and the environment from 1975 to 2008. The partnership with EROS has strengthened CRESA's experience with remote sensing. Since rural livelihoods are so intricately intertwined with the use of natural resources, USGS is very interested in monitoring the condition of the resource base. CRESA is also seeking partnerships that will help them strengthen the use of geospatial tools in support of decision-making in the environment and agricultural sectors.

Analytical, Data, Technical, and Infrastructure Issues

The university recently obtained about 20 computer workstations for teaching GIS and remote sensing, as well as scanners, printers, and plotters through grants from the West African Monetary Union and the Agency of French Communities. ERDAS Imagine and ArcGIS are being installed, with licenses being provided from a server over a network, but they still lack some up-to-date software. Training is needed for faculty, particularly in the theory of remote sensing and in the use of advanced software. The trainers also need refresher courses to stay abreast of these fast evolving technologies. Medium and high resolution remotely sensed data and mapping at 1:50,000 are needed for teaching and research projects, particularly over areas with rapid urbanization.

Capacity and Ability to Influence Decision Making

CRESA interacts with multiple government ministries, particularly in areas related to ecological surveillance. A formal partnership exists with the Ministry of Environment and Culture. The University's role in policy is primarily at the project level. Its designation as a Center of Excellence provides credibility and visibility to the government.

Summary Findings

None provided.

Institut Géographique National (IGN), Ministry of Urban Planning, Habitat, and Cadastral Mapping, Niger

Mission of the Organization

IGN's primary mission is to conduct cartographic activities, including national mapping, to ensure maintenance of the national territory. Key duties include GIS database development and harmonization of geographic information for all Niger.

Key Personnel

Hassimi Adamou, Director General
Mato Habouna, Technical Director

Geospatial Activities, Research, and Applications

IGN has 67 employees including 10 administrators, 19 technical staff, and 38 support staff. The Director General controls the Technical Division, but his administrators report to the Ministry of Finance. The Technical Division contains three divisions (Photogrammetry and Remote Sensing, Topographical Surveying, and Cartography) and a special section for Documentation, Marketing, and Public Relations. There is a Regional Service Office outside of Niamey which includes a small team for custom mapping and GIS development to serve the mining industry and other commercial interests.

Niger's 1:200,000 map series consists of 117 sheets for the entire country. IGN's highest priority is to complete 46 sheets in Southern Niger where there is the greatest potential for agriculture and forestry. In addition to paper maps, there are six layers of digital data including hydrology, soils, administrative and economic areas, settlements, road infrastructure, and topography. There is no plan to map all of Niger at 1:50,000. However, IGN hopes to map the Niger Valley (about 10% of the country) at that scale. IGN's software suite includes ArcView, ERDAS Imagine, and Adobe Illustrator.

Current Collaboration Efforts

IGN collaborates with RECTAS in Nigeria, and has a formal Memorandum of Understanding with IGN France. Other partners include Fugro and SPOT Image. IGN participates in the Global Spatial Data Infrastructure under an SDI grant. Strong collaborations exist between the IGNs of all neighboring Francophone countries, all of which belong to the l'Organisation Africaine de Cartographie et de Télédétection (OACT). The Japanese Global Mapping Project also funds Niger to degrade its 1:200,000 series to fit the 1:1,000,000 global series.

Analytical, Data, Technical, and Infrastructure Issues

Niger's Geodetic Datum is based on the UTM Clark Ellipsoid, an almost defunct system. They are currently moving to GPS/WGS-84 and hope to produce a total revision of the 1:200,000 series. Niger's Ministry of Communications is currently involved in a project to install a fiber optic cable similar to those in neighboring countries.

Capacity and Ability to Influence Decision-making

IGN's Director General has personally undertaken a mission to harmonize GIS data among agencies. He hopes to promote the value of geographic information to decision-makers, including security and territorial authorities. These activities, if successful, will eventually create the conditions for geospatial research activities from throughout the government to affect policy decisions.

Summary Findings

None provided.

Abuja Geographic Information Systems (AGIS), Nigeria

Mission of the Organization

AGIS is responsible for the digital cadastral mapping of the Federal Capital Territory (FCT) of Abuja.

Key Personnel

Ismail Iro, General Manager
Roland Klaus, Project Manager.

Mr. Klaus is an employee of Julius Berger Nigeria PLC who works under contract to AGIS and is clearly a key member of the AGIS team.

Geospatial Activities, Research, and Applications

With a staff of 240 working in a building suitable for half that number, AGIS collects land records and documents including certificates, deeds, and plats in hard copy and digitizes all text and plat data. They issue official Certificates of Occupancy and deeds. AGIS has an outstanding procedural approach to cadastral mapping. The staff is digitizing land surveys amounting to more than 200,000 records. This type of system is exactly the sort of cadastral operation that is needed in emerging democracies and war torn countries where land records are needed to support the return of displaced persons. It will be essential as well in any country that shifts from communal land tenure to private land ownership.

Similar to the system in Mexico, AGIS issues Certificates of Occupancy. The front side of the certificate itself contains a legal contract, a photo of the occupant, and a 20-character code that identifies the record but also serves to encode real data and information about the parcel. The back side of the sheet contains a plot of the property. The Minister signs the front, and the Director of Surveying signs the back, making it a Certificate of Occupancy, but not yet a deed. It becomes a deed when it is signed by the Register of Deeds. The GDEST team toured the rooms where each step in the digitization was taking place and also where title searches were being conducted. Most impressive was the large public room where throngs of landowners waited for their turn to file for certificates of occupancy, deeds, or transfers of ownership.

Everywhere the GDEST team visited—Dakar, Ouagadougou, Niamey, Abuja, and Cape Town—people expressed the need for cadastral mapping to support better land tenure systems. This was true even when the team met with other kinds of geographic organizations—national mapping institutes, geography departments, GIS institutes, earth science centers, government computing centers, GIS vendors, and others. At AGIS the team saw that dream in action being accomplished in a superb fashion. The only notable disappointment is that it is being done only for the Federal Capital Territory and not for the whole country, and there is no plan to extend cadastral mapping to the rest of Nigeria.

In conjunction with this cadastral mapping effort, the FCT just last year established proper house numbers for the first time in Nigeria's history, a step that will be needed in many other countries such as emerging democracies and war torn nations.

Current Collaboration Efforts

The greatest need for AGIS is training. Training is conducted mostly in-country and at conferences and international events including the Intergraph Users Conference (USA), GEOSON, FIG Africa (Accra) & FIG International (Munich), Emerging Urban Africa, Department for International Development (DFID), Nigerian Field Society, Abuja@30, and Dubai, where Dr. Iro won the award for best presentation.

AGIS used to work with the National Remote Sensing Center in Jos, Nigeria but it had such outdated equipment that AGIS discontinued the effort.

Analytical, Data, Technical, and Infrastructure Issues

Mr. Klaus has concluded that any project in West Africa takes about 30 percent more funding than the same effort would in the United States or European Union. The cost of uninterruptible power supply (UPS) is a big part of the expense. Another expense is the cost of direct satellite link, the only reliable telecommunications option.

AGIS' software suite includes Intergraph Geomedia Pro, and ArcGIS Data. The effort relies heavily on orthorectified imagery at resolutions finer than 1 meter. Originally, the imagery came from QuickBird, but they later switched to IKONOS. The cost is about \$300,000 for FCT coverage. The raw data reside at AGIS, but all processing is done elsewhere.

Capacity and Ability to Influence Decision-making

AGIS is a technical, production-oriented agency. They have no direct role in policy except with regard to land tenure policy. However, the data they produce should be considered in other policy areas such as economic development. Many U. S. states, for instance, have GIS-supported economic development offices that use cadastral databases to find available sites that meet environmental and production requirements of businesses being recruited to locate in the state.

At present, the AGIS officials tout their support of activities involving land revenue (tax assessment and taxation), and land-related infrastructure, services, administration, and businesses. AGIS aims to serve government, professionals, and citizens by raising the importance of secure land tenure systems and the information systems needed to support them.

Summary Findings

AGIS seems to be performing its function quite well on its own, though its services should be expanded to all of Nigeria. The AGIS operation can and should serve as a model for other countries looking to help build their economies through cadastral mapping.

USAID Famine Early Warning System Network (FEWS NET), Nigeria

Mission of the Organization

The Famine Early Warning Systems Network (FEWS NET) is a USAID-funded activity that collaborates with international, regional and national partners to provide timely and rigorous early warning and vulnerability information on emerging and evolving food security issues. See FEWS NET/ Burkina Faso.

Key Personnel

Yahaye Tahirou, National Representative
Victor Ajieroh, Southern Coordinator
Wayne Frank, Agriculture Development Officer

Geospatial Activities, Research, and Applications

FEWS NET expanded to include Nigeria in the family of countries in 2007. The decision to expand its presence in Nigeria followed the food crisis in southern Niger in 2005. Experts realized that the situation in Niger was closely tied to the complexities of cross-border trade with Nigeria. FEWS NET/Nigeria's mission is similar to that of other country offices – to monitor food security throughout the country and to collect and provide regular assessments to the overall FEWS NET program.

One of the first exercises for FEWS NET was to divide the country into livelihood zones. Within each zone, one finds similar characteristics including land use and land cover, climate, and shared sources of income and economic activity. The FEWS NET analysts make regular field visits including household surveys to build profiles of incomes, purchasing power and access to food. In Nigeria, the program tends to focus on the northern regions where there are current problems of food insecurity. Monitoring market price trends is one of the key indicators, along with analyzing remotely sensed time-series images to track seasonal vegetation growth and to estimate rainfall amounts, distribution and timing.

Nigeria poses particular challenges for monitoring food security. Firstly, the factors driving food production and food security are highly dynamic. Supply and demand forces are continuously shifting, with rapid flows from surplus to deficit production areas, under fairly liberal markets. Secondly, the food crop production in Nigeria is immense and very diverse. There are more than 25 food crops. With environmental diversity, deficits in one area can often be compensated. The urbanization of the population is driving a huge market demand for a variety of food crops. Thirdly, policies in Nigeria are crucial in determining what happens in terms of food production. The crops that farmers choose to plant depend on subsidies and government prices for commodities as well as assistance with inputs. Access to fertilizer is a major limitation. Maize, for example, does very poorly without fertilizer.

Analytical, Data, Technical, and Infrastructure Issues

Unlike the Sahel countries of West Africa, the network of partners that share food security data, analyses and information is very weak in Nigeria. There is a lack of good quality, up-to-date spatial information on key geographic themes that FEWS NET needs for its analysis, particularly in mapping longer term structural (vulnerabilities to hazards, droughts, and shortfalls in food production).

Capacity and Ability to Influence Decision-making

As with all the national FEWS NET units, analyses and map products on food security provided by the Nigeria unit provides very useful and timely information to decision-makers at USAID. By expanding its presence to Nigeria, FEWS NET is well poised to monitor food security conditions in the country, particularly in the semi-arid north where settled farmers and pastoralists live in regions which are known historically for problems of climate uncertainty and shortfalls in food production.

Summary Findings

The GDEST visit to FEWS NET/Nigeria was a courtesy call to better understand how the program uses geospatial technologies to monitor complex issues of food security and identification of populations at-risk. The visit was primarily for informational purposes, rather than for formulating future cooperative projects with FEWS NET.

Federal University of Technology (FUT), Minna, Nigeria

Mission of the Organization

FUT Minna is one of seven federal science and technology universities in Nigeria.

Key Personnel

Muhammed Audu, Vice-Chancellor
 P.S. Akinyeye, Head, Department of Geography
 M. T. Usman, Director of Collaboration, Affiliation, and Linkages
 Suleiman Sadiku, Faculty member
 Appollonia Okhimamhe, Faculty member

Some faculty members are part-time lecturers, with positions in government agencies.

Geospatial Activities, Research, and Applications

FUT has B.S., M.S. and PhD programs in the schools of science, engineering, agriculture, and environment. The Department of Geography is 20 years old and has an 18 year history in remote sensing. The staff presented an overview of recent university research, including a collaborative study with the federal Climate Change Center at the Nigerian Research and Development Agency that used SPOT, Landsat, NigeriaSat, and SRTM to develop flood risk maps. Other projects included a study of water quality in Kainji Lake (UNESCO funded) on the dammed Niger River and studies of aquaculture and fisheries in Shiroro Lake. Future research is planned to characterize the physical and chemical properties of water to determine the aqua potential for various lakes, as fisheries production is decreasing over time. Future work on water resource management is also planned for the Niger River.

Current Collaboration Efforts

FUT researchers carried out several collaborative projects with the Nigerian Space Agency and other government agencies. The university intends to aggressively pursue linkages with international institutions.

Analytical, Data, Technical, and Infrastructure Issues

FUT is developing infrastructure extremely rapidly in response to growing student enrollment. New buildings, a digital library, a multimedia classroom, and computing laboratories to accommodate 200 systems are nearing completion, with computer hardware recently installed and software (including ERDAS and ArcGIS) installation in progress. Distance courseware (e.g. MIT and Rice University) is facilitating course development, despite a lack of textbooks. Bandwidth for internet connections is problematic, but improving. The cost of access to remotely sensed data, including from NigeriaSat, is a significant problem. High resolution data was noted as a particular need.

Capacity and Ability to Influence Decision-making

The university is growing extremely rapidly and will inherently influence decision making at least through the large number of students moving on to work on policy-relevant projects. In spite of funding challenges, the university appears to be on a trajectory to expanding its influence on decision making through its research projects.

Summary Findings

None provided.

National Emergency Management Agency (NEMA), Nigeria

Mission of the Organization

The mission of Nigeria's Emergency Management Agency (NEMA) is to coordinate resources for efficient and effective disaster prevention, preparedness, mitigation, and response. NEMA officially reports to the Office of the President and the nominal head of the agency is the Vice President of Nigeria.

Key Personnel

Audu-Bida, Director General
 Dr. Halilu Ahmad Thaba, Head, GIS Unit
 Kayode Fagbemi, Head, Mission Control Center

The DG is a retired Nigerian Air Force officer with 33 years as a helicopter pilot. He has extensive exposure to the United States and has previously received training at the military base in Montgomery, Alabama.

Geospatial Activities, Research, and Applications

NEMA is Nigeria's counterpart to the U.S. Federal Emergency Management Agency (FEMA). The biggest difference is that because of Nigeria's weakness and lack of resources at the state and local level, the federal government is burdened with much, if not all, of the responsibility to protect the population. The federal government's responsibilities are heavy as it continues to try to improve the capacity of grassroots and state-level disaster responses. This is a huge challenge given NEMA's limited resources.

NEMA is interested in harnessing geospatial technologies for all aspects of disaster management, including preparedness, prevention and response. The list of disasters that are particularly relevant to Nigeria includes drought, famine, locust infestations, floods, and health-outbreaks (meningitis, measles, malaria, etc).

NEMA's GIS laboratory is equipped with software: IDRISI-Kilimanjaro, ERDAS, and ESRI products. During the walkthrough of this lab, staff expressed interest in the potential use of GIS for improving their understanding of the road safety problems in the country. Road fatality figures in Nigeria are extremely high. The problem seems to be getting worse as road congestion and traffic in the towns and cities worsens. The issue becomes an interesting public health problem that could potentially be better addressed using data and information generated by geospatial technologies.

NEMA's Mission Control Center features a large screen display showing the location of vessels and aircraft using their Emergency Beacon Search and Rescue. Locator beacons for ships, aircraft and persons are used in the Gulf of Guinea and have obvious applications in the oil producing, offshore areas of the country. The signals from these beacons can be displayed on the screens of the Control Center. There are multiple applications for these technologies in navigation, search and rescue, and basic public safety.

NEMA is dependent on accessing good communications technology from other federal agencies, which sometimes they access from their military. The Nigerian military, especially the Nigerian Air Force, provides much of the transportation and communication support during disaster simulations, training exercises, as well as during actual disaster response operations.

Current Collaboration Efforts

NEMA serves as the point of contact for West Africa in the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER). They have attended the United Nations International Strategy for Disaster Reduction (ISDR) meetings in Geneva and also participated in training programs sponsored by FEMA.

Analytical, Data, Technical, and Infrastructure Issues

NEMA is affected by data policy issues dealing with prices and sharing protocols among Nigerian agencies. NEMA also works closely with the Nigerian Space Agency in planning new satellite missions. They encourage Nigerian government dialogue on the design and implementation of national spatial data infrastructure legislation.

Capacity and Ability to Influence Decision-making

NEMA is a consumer of the data and information provided by Nigeria's communication and earth observation satellites launched by the National Space Research and Development Agency (NASRDA). Nigeria Communications Satellite (NIGCOMSAT-1) was launched by the Chinese for the Nigerians in May 2007. This is the first African communication satellite. India launched NigeriaSat-1 the earth observation satellite in September 2003. The spatial resolution of data from this satellite is 30 meters. NEMA expects to be a major consumer of data from NigeriaSat-2 data which was contracted for construction by Surrey Satellite Technology Limited of the United Kingdom in December 2006.

NEMA staff expressed the desire for additional cooperation, especially training and exchange opportunities, with the United States. They also want to access available satellite data of various spatial and temporal resolutions. They are particularly interested in more SRTM digital elevation data of their country, which have important applications in their delta region, and if possible at a 30-meter or better resolution. They specifically mentioned the need for high resolution IKONOS and SPOT-5 satellite data for applications in urban areas for disaster management.

Spatially explicit data on Nigerian population distribution were also discussed. A Nigerian census began in 2006 but has not been completed. Their National Population Commission is currently implementing projects, with assistance from DFID, to improve access to better population data for the country. NEMA stated their need for accurate population information in order to better fulfill their mission.

Summary Findings

NEMA has well trained personnel and a well articulated mission statement. Their burden is tremendous as they have to provide for all aspects of disaster management in a country of almost 140 million people. Their resources do not seem to be able to meet the needs of the task at hand. The government of Nigeria is investing considerable resources in improving the capacity of NEMA to better protect Nigeria from multiple natural hazards. There is clearly a great need, but considerable will on the part of the Nigerian federal government, to harness geospatial science and technology for disaster management purposes.

Nigeria Geological Survey Agency (NGSA), Nigeria

Mission of the Organization

The NGSA mission is to collect, archive, process, and manage data and information about the geologic resources of Nigeria. This includes basic geologic mapping of structural geology, tectonics, and mineral resources. NGSA is under the Ministry of Mines and Steel Development.

Key Personnel

H.O. Davies, Assistant Director

O. A. C. Ugwuja, Director, Applied and Engineering Geology Department

Geospatial Activities, Research, and Applications

NGSA has a staff of 600 people overall, including 290 geologists divided among four departments: Regional Geology, Economic, Applied and Engineering Geology, and Administration and Finance. The Regional Geology Department does basic geological mapping, and places great importance on using geospatial tools for geological mapping. It strives to update older maps, and to map the geology of the region at finer scales. It also has several national scale geologic maps, is completing a set of 1:100,000 geology maps, and is working to stratify the maps into zonal areas, including geology by administrative regions. Other activities that use geospatial tools include airborne geophysical mapping, regional geophysics, and focused mapping of mineral targets. Outputs include printed and digital maps in raster and vector formats. They use AutoCAD and ArcGIS and maintain databases on state mineral resources.

Analytical, Data, Technical, and Infrastructure Issues

NGSA is facing a major challenge in digitizing their maps, many of which existed only in paper format. There is a major problem of unavailability of primary datasets, particularly paper topographic. NGSA hopes to promote digital use by its potential customers.

Another challenge is that of data format, standards, and harmonization. Nigeria needs to make progress at a national level to promote geospatial standards to facilitate sharing among the geospatial community.

NGSA strives to provide training to their staff in geospatial tools through RECTAS in Ile-Ife. The need to keep their staff abreast of state-of-the-art developments in these tools remains a continuing challenge as does the need to train more staff in specialized areas.

Another challenge faced by NGSA is improving their topographic mapping in areas of persistent cloud cover in the southeast. The agency requested assistance in acquiring 30-meter SRTM data to help with the digital elevation model of this region.

Capacity and Ability to Influence Decision-making

NGSA's wealth of geological and mineral data is used extensively in exploration and prospecting for oil and other minerals used by both industry and government institutions. The Ministry of Water Resources is another customer of their hydrological and water quality maps and data.

Summary Findings

The field of digital elevation mapping with SRTM image data is a possible point of collaboration with the USGS International Program Portions of 30-meter SRTM data have been released on a case-by-case basis. If NGSA were able to obtain the data, USGS could provide technical assistance in this area.

GeoQinetiq, Nigeria

Mission of the Organization

GeoQinetiq is a consulting company that focuses on providing services and technology for surveying, mapping, and remote sensing projects in Nigeria. It is a Nigerian distributor for Leica and provides geospatial technology to universities, decision-making institutions, and businesses. GeoQinetiq has an emphasis on training for long-term sustainability of projects.

Key Personnel

Juliet Ezechie, Managing Director and CEO based in Lagos.

Her academic background is in geodesy from the University of Nottingham with a graduate degree from University of London. She started her career in the United Kingdom working for Leica, Inc. and then subsequently worked for many of the German and other European high-technology conglomerates involved in the Galileo Global Navigational Satellite System constellation.

Geospatial Activities, Research, and Applications

GeoQinetiq works with the Education Trust Fund (ETF) of Nigeria, an entity funded by taxes on the oil industry. By Nigerian law, two percent of all the profits of extractive industries, including oil, must go to ETF which re-invests the funds in education. Much of that investment goes into infrastructure projects in primary and secondary schools. GeoQinetiq has helped the government work on projects to help boost geospatial technology in higher education. Ms. Ezechie noted that in many instances, Nigerian universities trained geography students using outdated technology, and sometimes even without computers. She emphasized the importance of building capacity in education and training. She has seen equipment sitting idle because of a lack of technical knowledge on the part of the users.

Current Collaboration Efforts

Ms. Ezechie noted that the governor of the Lagos State, Babatunde Fashola, is a key partner and champion of government investment in upgrading geomatics and surveying capacity in Nigeria. Fashola, a lawyer by training, is starting a mapping drive for the entire state and has supported other statewide initiatives related to geography. He is working with ten key states committed to improve surveying and mapping in the country. In Ms. Ezechie's opinion, his actions will lead to other Nigerian states to follow because their leaders will not want to be left behind.

She is currently involved in a government project that is upgrading the surveying capacity of seven institutions through a five-year educate-the-educators program. She seemed particularly aware of the business case for investing in training the trainers in order to raise surveying and mapping skills and capacities across Nigeria.

GeoQinetiq is working with University of Lagos Department of Surveying and Geomatics on a continental shelf mapping project. Dr. Peter Nwilo at the university is collaborating with the U.S. Navy's Office of Naval Research (ONR) on this and other projects.

Analytical, Data, Technical, and Infrastructure Issues

Ms. Ezechie discussed the problem of corruption and "commissions" for facilitating large sales of modern equipment to the government. These contract sales fail to help achieve project goals because of a lack of local capacity to use the technology.

Capacity and Ability to Influence Decision-making

Ms. Ezechie seems to have the trust of some key Nigerian leaders and businessmen. She is a valuable consultant who gives advice in framing or preparing the terms of reference for any mapping project in Nigeria. She insists upon inserting a five-year technical support contract in any geodetic equipment that she sells and feels this type of training and support is the only way to make projects both sustainable and successful. She ensures that any sales she makes include a provision that increases local capacity and long-term sustainability.

Summary Findings

Ms. Ezechie has extensive experience in the mapping private sector. As a dual British and Nigerian citizen, she is strategically placed to act as a bridge between Nigeria and the United Kingdom on geospatial projects in which she is involved. She also has excellent connections in the academic and government sectors (at the local, state and federal levels) of Nigeria and has a strong interest in raising Nigerian capacities in surveying and mapping.

National Space Research and Development Agency (NASRDA), Nigeria

Mission of the Organization

NASRDA was established in 1999 and reports directly to the Federal Minister of Science and Technology. As the national space agency, it has the mandate to develop and implement an indigenous space science and technology program whose goal is to advance Nigeria's position in the international space community and to support strategic national initiatives related to sustainable development.

Key Personnel

NASRDA currently employs approximately 300 people. The following individuals attended the GDEST Africa meeting and provided contact information. Note the heads of the centers above.

Dr. Robert A. Boroffice, Director General and Chief Executive
 Dr. Joseph O. Akinyede, Director, Space Applications
 Dr. Olufemi A. Agboola, Deputy Director, Engineering and Space Systems
 Dr. Ganiy Agbaje, Head, Mission Control and Data Management

Geospatial Activities, Research, and Applications

NASRDA activities are conducted through six centers:

- 1) Centre for Basic Space Science (CBSS) Nsukka. The focus of CBSS is research in atmospheric science and astronomy (Head: Prof. P.N. Okeke);
- 2) National Center for Remote Sensing (NCRS) Jos. NCRS has primary responsibility for research and development in applications of remote sensing, GIS, and related technologies. NCRS operates the ground station and is tasked with operational services, including product sales, disseminating information about remote sensing data within Nigeria, and developing local and international collaborative activities. (Head: Prof. J.F. Olorunfemi);
- 3) Center for Satellite Technology Development (CSTD) Abuja. CSTD has responsibility for developing satellite payloads for remote sensing and communications and for developing the critical numbers of engineers and scientists required to support all aspects of satellite development, launch, and control, and data acquisition and delivery. (Head: Prof. J.I. Ejimanya);
- 4) Centre for Geodesy and Geodynamics (CGG) Toro. This highly technical center focuses on developing the capability required for precision applications associated with surveying and mapping, mineral exploration, coastal subsidence and deformation, and global mean level monitoring. (Head: T.A. Yakubu);
- 5) Center for Space Transport and Propulsion (CSTP) Epe. Development of capability in rocket and fuel technologies and civilian and military launch operations is the focus of CSTP. (Head: OA. Fashade); and
- 6) Centre for Space Science and Technology Education (CSSTE) Ile-Ife. The Centre is affiliated with the United Nations and serves as the African Regional Centre for Space Science and Technology Education in English speaking countries. It is also charged with developing the capacity of university educators in areas required by the other Centres. (Head: Prof. O.O. Jegede).

Nigeria links advances in space technology to security and preeminence in the international community. The long term goals of NASRDA include training of a Nigerian astronaut (2015), launching satellite manufactured in Nigeria (2018), and launching a satellite from a Nigerian launch site (2025).

NASRDA's NigeriaSat-1 microsatellite initiative included technology training for 15 Nigerian engineers and scientists. The satellite is part of the Disaster Monitoring Constellation (DMC), with satellites belonging to Algeria, China, Turkey, and the UK. It has a 600 km swath width and provides data in three bands with an effective 32m spatial resolution, providing some overlap capability with Landsat. The NigeriaSat-2 satellite will carry a 4-band camera for acquiring multispectral data at 5m and panchromatic data at 2.5m. The satellite will also have increased recording and transmission capability and improved navigation. It will provide continuity with NigeriaSat-1 and increased capability for higher resolution applications in urban mapping, agriculture, natural resource management, disaster response, and population estimation.

The Chinese-designed and launched NIGCOMSAT-1 communications satellite was built as a hybrid geostationary satellite with C, Ku, Ka, and L microwave bands to provide increased Information and Communication Technology (ICT) capability, covering Africa and parts of the Middle East and Europe. It

provides improved telephone and data transfer services, as well as a local navigation and improved global positioning system capability.

Both the NigeriaSat-1 and NIGCOMSAT satellite programs include provisions for training Nigerian engineers and scientists to manage the current systems and lay the foundation for future design and launch capability within Nigeria.

Current Collaboration Efforts

Nigeria is a member of the Disaster Monitoring Constellation (DMC), whose members include Algeria, China, Turkey, and the U.K., and whose focus is providing daily, medium resolution data in three spectral bands over Africa. In 2005, the DMC also joined the International Charter on Space and Major Disasters. NASDRA actively participates in the African Association of Remote Sensing of Environment, the Committee on Earth Observation Satellites (CEOS), The Committee on Peaceful Uses of Outer Space (COPUS), the Group on Earth Observations (GEO), and the Committee on Space Research (COSPAR).

Analytical, Data, Technical, and Infrastructure Issues

The permanent site for NASRDA is now located outside Abuja at the new Obasanjo Space Center complex, where construction of new facilities is still ongoing. The satellite ground station will soon be moved to the complex, where it will be permanently located. Data are currently processed at the National Center for Remote Sensing (NCRS) and delivered to users via CD or DVD, which impacts usage, particularly for monitoring activities.

Data from the NOAA Advanced Very High Resolution Radiometer provide regional scale measures of vegetation greenness (Normalized Difference Vegetation Index) at daily time scales through local ground stations. Historical free Landsat data are being used for projects, and more recent Landsat and SPOT data are purchased on a limited basis for individually funded projects. The 90m international topographic product from the Shuttle Radar Topography Mission is now being utilized, in conjunction with data derived from digitization of maps and aerial photography. However, persistent cloud cover over much of Nigeria limits the effective use of remote sensing data. The country is negotiating for a direct downlink of the European TerraSAR-X synthetic aperture radar data and exploring long term investment opportunities using SAR satellite technology.

A high level of competence exists in a limited number of individuals for developing and operating the Nigerian space program. Most of these engineers and scientists have been trained in other countries. Some have been involved with other countries' space programs. Advanced training for many more engineers and scientists is needed. The University of Lagos and the Federal University of Technology, Minna are training students for the space program. Other students have received training on focused short-term international training programs

Capacity and Ability to Influence Decision-making

Widespread acceptance of the importance of data standards, access, and harmonization has resulted in a national policy for geographic data. Implementation is underway and should have a major impact on decision-making at the federal, state, and local levels. Direct report of the NGDI Council to the Vice President underscores the commitment to this issue.

NASDRA is involved in a wide range of remote sensing and GIS demonstration projects for sustainable development. It has also organized workshops in such wide-ranging topics as NigeriaSat-1 data validation and applications, space education, global navigation systems, and space law, and space leadership in Africa. The visibility is high, but the full impact of the space program as an effective operational agency is yet to be realized in terms of data access and utilization.

Summary Findings

Nigeria has ambitious programs underway in expanding effective utilization of geospatial data and in remote sensing from space. Lack of bandwidth for high speed data transfer and a limited cadre of scientists and engineers appear to be the most limiting factors in effective utilization of NigeriaSat-1 remote sensing data. Development of the communications infrastructure is indicated as high priority. A variable fee structure for remote sensing data has been implemented for cost recovery. Although inexpensive compared to commercial data in Europe and the U.S., the cost effectively reduces access to and development of

applications. These issues, as well as data archiving and dissemination should be addressed prior to the launch of NigeriaSat-2.

A strategic investment by the U.S. to support training of faculty in advanced applications of remote sensing could bolster NASDRA's efforts to foster research throughout Nigeria. Developing partnerships with universities that focus on strategic applications could be one component of such an initiative, though travel to the U.S is limited by visa issues and cost. Support of shorter-term training courses in conjunction with international conferences could also be effective. Prior to the launch of NigeriaSat-2, targeted acquisitions and delivery of high resolution multispectral and panchromatic data for urban mapping and disaster response could also prove to be a fruitful collaboration.

Appendix 2: Team East Site Visits

Office of the Prime Minister (OPM), Department for Disaster Preparedness and Management, Uganda

Mission of the Organization

The Department for Disaster Preparedness and Management implements Uganda's National Disaster Risk Reduction and Management (DRRM) Policy. The goal of the policy is "to establish institutions and mechanisms to reduce Uganda's vulnerability, effectively manage existing risks, and enhance preparedness and response capability to likely disasters."

Key Personnel

Mr. Johnson Owaro, Coordinator for Disaster Preparedness, Office of the Prime Minister.

Mr. Owaro holds a master's degree in agriculture from Makerere University in Kampala. His Master's Degree was funded by USAID, which he appreciatively mentioned, and he traveled to the U.S. to present a paper at Penn State University during an agricultural economics conference. He followed up on a request made during the first meeting, offering to organize a lunch meeting the following day with a close colleague and friend of his, Mubiru James William, who is Deputy Executive Director of Uganda's Bureau of Statistics.

Geospatial Activities, Research, and Applications

The government has carried out some hazard and assessment mapping and developed hazard maps for earthquakes, landslides, floods and drought. While Mr. Owaro supports increased GIS and remote sensing use, his staff is not currently using GIS technologies extensively. The geospatial applications primarily involve the examination and use of maps or imagery provided by others-- not production of GIS maps or data, or the computerized analysis of geospatial data. The department is seeking support from UNDP and other donors for GIS staff and facilities. Mr. Owaro is also working toward the development of a GIS Data Center, which he suggested might be located at the Bureau of Statistics. He has used satellite imagery, but cited the difficulty of receiving satellite imagery from UNEP and UNDP in a timely manner. The received imagery was also insufficient resolution for use during the extensive flooding that occurred throughout northern Uganda in 2007. Mr. Owaro stated that obstacles to implementing GIS at the Department are lack of personnel, low salaries, competition for trained employees from higher paying NGO organizations active in the region, and limited data of sufficient detail directly related to emergency response and management needs.

Current Collaboration Efforts

Extensive collaborative activities take place among government agencies and with international and regional organizations. Being located within the Office of the Prime Minister greatly facilitates interagency coordination of activities. The OPM links multiple ministries responsible for various facets of disaster preparedness, and an inter-ministerial Committee on Disaster Risk Reduction and Management helps coordinate. For example, the department coordinates implementation of its DRRM Policy with other agencies charged with implementing programs of the National Development Plan/Poverty Eradication Action Plan, which includes issues related to disaster vulnerability and response capability. In addition, the department is currently working with the Department of Meteorology to launch a radio and internet program (Radio-Net) to rapidly disseminate disaster preparedness and response information. While collaboration on the program appears to be working well, it is challenged by the same personnel issues (high turn-over of technical staff, technical training requirements of end-users, etc.).

The Department for Disaster Preparedness and Management also coordinates with district- and sub-county-level Disaster Management Committees established in the most vulnerable districts and regions. Mr. Owaro travels extensively throughout the country, working at the grassroots level, particularly in the heavily flooded areas and in the conflict strained northern Uganda.

The department also collaborates externally with NGOs, UN agencies, and regional and international governmental organizations. The staff works particularly closely with UNDP and UNISDR (UN International Strategy for Disaster Reduction), and to a lesser extent with UNEP. Regional collaborations include the Africa Regional Center for Space Science and Technology in Nigeria and efforts to promote coordinated drought risk reduction activities throughout Africa, such as the first African platform on Disaster Reduction.

Mr. Owaro also maintains close collaborative contacts with faculty at Makerere University, his alma mater, particularly with those in the two departments of Environmental and Natural Resources and Geography. He is interested in pursuing a doctoral program at some point in his career, a move strongly encouraged by Makerere officials. He also has several private sector contacts and entertains public-private project proposal ideas. DRRM policy encourages collaboration with civil society organizations (CSOs), but such action appears lacking.

Analytical, Data, Technical, and Infrastructure Issues

Mr. Owaro emphasized the need for more detailed and timely data, and sees this as a significant obstacle to effective use of geospatial technologies in the department. He indicated that during the 2007 flooding disaster in northern Uganda, he could not obtain useable imagery for several weeks after the initial flooding occurred. What imagery that he was able to acquire eventually from UN agencies was not of sufficient resolution for effective response planning. In addition, very little of the necessary related data, such as stream gauge data or meteorological data, is collected from northern Uganda. Related data would enable predictive spatial modeling or advance warning of flooding events. Much of the water entering this region flows in from Sudan to the north. Sudan and Uganda have little or no coordination on data related to stream flows, if indeed such data exists at all. Civil strife in both northern Uganda and southern Sudan has exacerbated these data problems and poses significant obstacles to its timely resolution.

The GDEST team suggested that the department coordinate with U.S. Government agencies to explore options for meeting some of its emergency response imagery data needs, and that some of the detailed rapid disaster assessment data needed might be collected by aerial or on the ground GPS/GIS field data collection systems. Obstacles to using these data sources and products effectively in preparing for and responding to disasters in Uganda include the current lack of sufficiently trained technical personnel, equipment and related digital data infrastructure.

As indicated above, inadequate technical and analytical expertise and related hardware, software and data infrastructure within the Department for Disaster Preparedness and Management are significant obstacles to achieving its goals of using geospatial science and technologies to better prepare for and respond to Uganda's frequent and serious disasters. Developing this capability in the near future will require partnerships with others, including with other governmental agencies, universities, and perhaps NGOs and the private sector could be important sources of needed expertise and local capacity building support.

Capacity and Ability to Influence Decision-Making

The Department for Disaster Preparedness and Management's location in the Office of the Prime Minister gives it unique opportunities to influence decision-making. Recent major national disasters, including the extensive floods in northern Uganda, have given a high profile and urgency to the focus of this Department's mission and work. To the extent that the department's mission also supports important national needs for security and emergency preparedness related to disasters produced by conflict in the northern part of the country the need to develop effective disaster response capabilities in Uganda is clearly pressing. Further discussions with officials within the Department for Disaster Preparedness and Management, and also within the Office of the Prime Minister, would be necessary to determine the degree to which this department and support for its activities would influence decision-making.

Summary Findings

None provided.

Makerere University Institute of Environment and Natural Resources (MUIENR) and Department of Geography, Uganda

Mission of the Organization

Makerere University was viewed by some as the finest in Africa in the 1970s. It is slowly rebuilding its capacity with new buildings and faculty, and has a total student population of about 10,000. MUIENR is part of Makerere University. Movement is underway to establish many private universities in Uganda. The first is the Kampala International University, but ten are currently planned nation-wide.

Established in 1988, the MUIENR provides leadership in and knowledge about natural resources, for human benefit and protection of the environment. It is the principal center for GIS training in Uganda.

Key Personnel

Dr. Frank Kansiime, MUIENR Director
Charles Basalirwa, Professor of meteorology
Yazidi Bamataze, Associate Professor

MUIENR currently has nine faculty members and has plans to add five more.

Geospatial Activities, Research and Applications

MUIENR has curricula for a B.S. in Environmental Science and M.S. in Environment and Natural Resources, fostering interdisciplinary study and research between the schools of engineering sciences, ICT, geography and environment and natural resources. Courses in GIS data sourcing, tools, applications and research are integral to the curricula. Usually 70-80 students are enrolled in the BS program which has a capacity to expand to 150. Of the students, 120-150 have matriculated with masters degrees and there have been 25 doctoral students with an additional 10 doctoral students currently working on their theses. The Department of Geography has a modest but increasing interaction with the MUIENR, and students attend GIS classes organized by the Institute.

MUIENR serves many government institutions: the National Environment Management Authority, Forest Department, Uganda Wildlife Authority, Wetlands Program, and Lake Victoria Environmental Management Program. MUIENR is supporting its clients by producing maps and applied analysis for the central and district government authorities. The demand for maps and analysis is proliferating in number due to political gerrymandering--districts have increased from 54 to 83 in the last two years. With a \$20,000 Rockefeller Foundation grant, MUIENR is beginning to provide GIS training to district and local government analysts. MacArthur Foundation has also been a large source of grant funding.

MUIENR graduates are in high demand, particularly in the fields of urban planning, watershed management, and tourism. Kansiime believes that the critical issues for the near term are solid waste management in the urban settings, cholera and malaria forecasting (based on blooms in Lake Victoria, for example), and identifying better areas for increasing food sources such as millet and banana with seasonal forecasting and soil mapping. (Note: USAID is currently funding bioengineered, disease-resistant banana trials in Uganda.) MUIENR was apparently not involved in supporting the "Review and Analysis of Existing Drought Risk Reduction Policies and Program in Uganda," which was published in February 2008 under the auspices of the Ministry of Agriculture, Animal Industry and Fisheries and the Office of the Prime Minister, Department of Disaster Management, with the support of Acacia Consultants, Ltd., UN International Strategy for Disaster Reduction and the Swedish International Development Cooperation Agency (SIDA). The report recommends strongly increased capacity for holistic approaches, contingency planning, knowledge management, and promotion of best practices, including related education as "a priority for academic, scientific and technological institutions at the national level". The report contains no direct reference to Makerere University, MUIENR, or GIS assets and tools.

Analytical, Data, Technical, and Infrastructure Issues

MUIENR has a traditional library, two computer laboratories with about a dozen stations each, eight hand-held GPS devices, and a wide carriage printer for map making. The Institute purchases all of its imagery requirements. With \$50,000 funding from the MacArthur Foundation, Kansiime was able to install Internet connections in the labs and faculty offices. In the near future he expects the MacArthur Foundation to award

an additional grant for collaborative research. The Rockefeller Foundation is also providing an unspecified amount to foster support for business and commerce. Kansiime provided the team documentation of the BS and MS curricula, as well as his contacts at the MacArthur and Rockefeller Foundations. Apart from learning that Kansiime is authorized to increase his staff, the U.S. team was unable to determine if the central government is devoting sufficient funding to maintain the Institute's capacity and research.

Kansiime identified data centralization as a significant problem. The university maintains data from its researchers, but Uganda lacks a central repository for all public and private users. This issue is the subject of intense internal debate and was discussed with several of the team's interlocutors during the visit. As a result, MUIENR must purchase access to its most critical data sites.

Kansiime mentioned internet access as MUIENR's second significant problem. He also said a vision is needed to create a stronger GIS network including, data banks for national resources and soils. He sees his natural allies in the National Environment Management Authority and the Ministry of Environment, but access and influence are always difficult. He also mentioned his need to purchase software like ArcView and ARCGIS with his own resources.

Current Collaboration Efforts

Kansiime indicated his best collaborator is the Institute of Hydrological Evaluation (UNESCO Delft) where some of his students go for training and research. MUIENR also conducts research and exchanges with students from Sweden. He did not mention any current collaborators in the United States.

MUIENR participates in UNEP's Integrated Ecosystem Assessment activities. The MUIENR also collaborated with the START Project on Climate Change, but the World Conservation Society replaced MUIENR failed to fulfill its modeling assignment for the project. MUIENR lacks significant relationships with other universities in contiguous countries.

Summary Findings

Kansiime is part of a cadre of like-minded people who were educated together and now populate government and the NGO community. Others with whom the team met include Johnson Owaro in the Prime Minister's Secretariat, Eugene Muramira in the National Environment Management Authority, and Shuaib Lwasa at Urban Harvest Potato Center. This cadre appears to have growing rising influence in the policy-making and decision-making levels of the Ugandan government.

As a general matter, Kansiime observed that it is difficult to convince top managers about the need to fund GIS data and analytical resource requirements. The team said this was sometimes the case in the U.S. as well.

Productive Resource Investments for Managing the Environment – Western Region – PRIME/West, Uganda

Mission of the Organization

According to the project's website hosted at the USAID Natural Resource Clearing House, its mission is "to sustainably and equitably integrate the region's economy and people into the global economy." Using a Geographic Information System (GIS), the project merges landscape analysis with economic competitiveness so that local residents can earn an income while ensuring sustainability. The project's first component, landscape analysis, is the systematic analytical and planning process that examines specific economic opportunities available to people in southwestern Uganda. It is used to plan interventions, direct resources, and monitor change. Activities that degrade the environment and are ultimately unsustainable do not move forward. The project's second component, economic competitiveness, ensures that activities are economically viable at the household, community, and regional levels.

Key Personnel

Dr. Panta M. B. Kasoma, Chief of Party for PRIME/West.

Dr. Kasoma obtained his doctorate in ecology in the United Kingdom at King's College at Cambridge. Dr. Kasoma has extensive experience with the development and implementation of community development projects related to agricultural development and conservation activities, especially in the southwestern Uganda.

Geospatial Activities, Research, and Applications

An expatriate from Holland used GIS tools in the early phase of PRIME/West efforts to demonstrate crop suitability for local and district decision-makers related to Community-Based Natural Resource Management (CBNRM) activities in southwestern Uganda.

PRIME/West has also sponsored training activities related to petroleum exploration in and around the Albertine rift. These training activities brought together participants from the World Conservation Society, the Uganda Wildlife Association, the National Forestry Association, and the National Environmental Management Agency.

Current Collaboration Efforts

Dr. Kasoma was not aware of some of the interdisciplinary activities of Dr. Frank Kansiime at the MUIENR. He was aware, however, that a prominent Ugandan academic, Dr. Sam Mugisha, who possesses strong GIS/RS skills, was on a one-year sabbatical with the Department of Environmental Sciences at the University of Botswana.

Analytical, Data, Technical, and Infrastructure Issues

Dr. Kasoma believes that GIS practitioners within Uganda have difficulty visually representing what is happening over time to decision-makers and policy makers. He is concerned that his sector is not able to effectively communicate the results and power of its activities in space or time to decision-makers. Dr. Kasoma also pointed out that local governments have a great deal of autonomy in the current Ugandan system and are sometimes isolated from development and corporate social responsibility activities of corporations.

Another philosophical concern of Dr. Kasoma is that too often Eastern African governments view completion of an environmental information system or an environmental impact assessment as the end of the process rather than the start of a process for collaborative activities to address the environmental concerns, needs and issues raised in those systems or assessments.

The disconnect between donors and the people on the ground represents a grand challenge for those utilizing GIS/remote sensing analyses and techniques to effect CBNRM. Dr. Kasoma pointed to an example where an on-the-ground assessment described the need to slowly build a relationship and trust with local communities to communicate geospatial information. The parties responsible for the ultimate oversight of the program outside of Uganda did not sufficiently understand the situation with the communities and the

need for this approach. Consequently, the outside funders shifted the focus and task of the PRIME/West activities in the middle of the project.

Capacity and Ability to Influence Decision-Making

In reference to outside interference in PRIME/West activities, Dr. Kasoma observed that the shift in project emphasis apparently undermined progress and extended the time required for building sufficient community understanding.

Summary Findings

None provided.

Urban Harvest, Uganda

Mission of the Organization

Urban Harvest's mission is to promote appropriate approaches for agricultural production in urban and peri-urban areas. Kampala serves as one out of 19 cities selected world-wide. The overall program focuses on land use planning as a means to develop an integrated solution to urban poverty.

Key Personnel

Shuaib Lwasa, Director

Geospatial Activities, Research, and Applications

Urban Harvest is a cross-institutional research program within the Consultative Group on International Agricultural Research (CGIAR or CG). In Kampala, it is housed within the International Potato Center. The Urban Harvest unit is small, consisting primarily of Dr. Lwasa, but unit engages collaborators (faculty and students) from the geography and social science disciplines at Makerere University, as well as the University of Dar es Salaam in Tanzania. The level of expertise in geospatial and sustainable development issues, education and training, publishing, and professional organizations is sufficient; however, the number of practicing engineers and technicians is inadequate.

In Kampala, Urban Harvest has been particularly interested in the means to address urban waste management. Urban waste is 75 percent biodegradable and may be used as organic material in urban and peri-urban gardens. This would require the creation of an effective mechanism to transport waste from its origins (at the household level) to the individual gardens. The Urban Harvest program uses imagery and GIS applications to map land use in peri-urban areas. They are employing community mapping approaches which integrate these data and applications with community knowledge. The CG system does employ a data platform for discovery and exchange of data as part of the GeoNetwork. However, the team did not determine whether the Urban Harvest or Potato Center in Kampala was actively engaged in data exchange.

Current Collaboration Efforts

Uganda recently experienced significant floods. The flood response (and disaster response in general) brought to light the need for an analytical and institutional framework to engage disaster response organizations or areas of expertise that can contribute to such responses. Clearly, the linkage exists between the CG center and universities. Engagement between the center and government or non-governmental agencies is less clear. For example, neither Urban Harvest nor the National Environmental Management Authority (NEMA) mentioned each other in terms of addressing urban environmental issues, though both recognized urban issues as being important.

Urban Harvest could take advantage of a collaborative data access process using imagery. It is not clear who, in the United States may be most appropriately engaged in such collaboration, but the Bureau of Oceans, Environment, and Science at the U.S. State Department does maintain an urban program that may offer points of collaboration.

Analytical, Data, Technical, and Infrastructure Issues

Lwasa has recognized that data access, standards and infrastructure are essential. He has become involved in national-level discussions on NSDI issues. The problem, as he points out, is the discrepancy between Ugandan agencies on data access and standards. Thus, the problem exists at the institutional, policy and technical levels. Internet connectivity and power availability, hardware and software, open source or proprietary, interoperability standards, geospatial tools, satellite and airborne sensors, are lacking.

Access to remote sensing either comes via direct purchases of imagery, through the RCMRD or via other distributed networks (GeoNetwork). Imagery remains very expensive for initial purchase. Distributed imagery via open networks depends upon sufficient bandwidth, which is frequently lacking. Urban Harvest does not use aerial imagery.

Capacity and Ability to Influence Decision-making

The Urban Harvest program does not aim to affect policy, but does engage in local decision-making within the context of its zone of research. This is done through participatory processes that engage the local community and applies mapping approaches. One of the challenges to CG-led efforts is precisely the connection to policy and the connection of policy to on-the-ground results.

Summary Findings

The Urban Harvest Program represents the ability of a relatively small organization to engage in cutting-edge activities with a very locally relevant impact. The combination of remote sensing, GIS and community participation is a useful model that may have broader adaptations. The program also demonstrates how local-level efforts can inform national spatial data infrastructure development. This process requires a mutual engagement between actors and definition of the actor's relative roles.

National Environment Management Authority (NEMA), Uganda

Mission of Organization

NEMA is the government agency responsible for coordinating, advising, and monitoring on all aspects of environmental work with other government departments to make sure environmental issues are handled. NEMA deals directly with ministries as well as with the districts.

Key Personnel

Eugener Muramira, Director of Policy, Planning and Information

Kitutu Kiomono Mary Goretti, Geologist responsible for supporting districts to meet MEMA requirements at the district level.

Geospatial Activities, Research, and Applications

NEMA administers a centralized approach to integrating information in a relatively weak central government. The districts are given the responsibility and authority to prepare their annual environmental assessment. NEMA is responsible for training the district staff to conduct local environmental assessments using a standard approach.

Districts are responsible for ensuring integration of environmental issues into district-level decision-making. Both district and national levels of government should ensure that environmental and natural resources data and issues are integrated into policies at their respective levels.

NEMA coordinates a biannual State of the Environment report which informs Ugandan of national environmental conditions. The report incorporates information from the annual district State of the Environment reports. These reports are available both in printed and digital form.

NEMA and the districts use data from numerous government agencies although not all the agencies have the most appropriate or current data. NEMA receives data from Lands and Surveys – standards, topographic and geodetic information; National Agricultural Resources Organization – Soils; U.K. Ministry of the Environment – biodiversity; and local governments – GIS integration of information.

Current Collaboration Efforts

NEMA collaborates with numerous organizations. NEMA collaborates with UNEP in Nairobi and produces publications that are, from UNEP's point of view, an excellent example of what nations should provide as environmental reporting. The overwhelming training demand by districts limits NEMA's ability to expand capabilities into more analytical and advanced areas. They would like to collaborate with others who have those capabilities, but they may not have the capacity to do so.

The widely available State of the Environment report sheds light on collaboration among national and district levels. NEMA receives data from other government agencies when it is available and interactions take place at the policy level.

Analytical, Data, Technical, and Infrastructure Issues

Budget constraints and yearly funding fluctuations for different programs within NEMA have resulted in a lack of consistent coverage thematically and over time. Sufficient resources are generally lacking to consistently update data. NEMA's funding for operations and the data collection comes from the national government and donors.

Population density data collection is problematic, resulting in uneven reliability for information in the national. Population data and information are needed to link environmental conditions to both their cause and effect, and to help others develop plans to improve the environment or to safeguard the health of the people.

NEMA's reports both in book and digital form posted on its website. Since internet penetration is low, the general population is not likely to access the reports on the web but reports are available in hard copy to requestors. ,

GIS capabilities at NEMA are limited. The GIS lab in the headquarters is small. Both administrators indicated there are insufficient personnel to take activities to the next level since they are responsible for training and assisting the increasing number of districts (now 83). They believe the next step would be to model and predict potential outcomes of various actions on the environment rather than focusing on purely descriptive reports.

Capacity and Ability to Influence Decision-making

NEMA believes that the nation supports an integrated assessment of the environment and tries to incorporate environmental issues into policy planning. At the macro level, the state of the environment reports demonstrates the importance of the environment in national economics. Linkages are drawn between environment and various sectors of the economy such as health. Policy makers refer to the report in speeches and in their actions. Parts of NEMA's reports are reaching the public by being quoted in newspaper articles.

Summary Findings

NEMA faces several challenges. Firstly, local governments require considerable training beyond the one week or five days provided by NEMA. Some receive no training and must learn independently. Secondly, since collecting data is expensive, NEMA often has difficulty updating relevant data. For instance, NEMA and the districts receive some data from the African Environmental Network and UNEP whose last data update was in 2000. Furthermore, software updates and additional seats for existing software are too expensive for their budget.

There are, however, several opportunities for improvement. For instance, universities and the Institute of the Environment & Natural Resources, Geography, and Civil Engineering can provide training and data if funding is available. NEMA also tries to influence policy, especially since the budget now frequently mentions environmental protection. NEMA does not do spatial modeling and they are not sure if such expertise exists in country. They still have problems integrating data sets due to differences in data standards. Data integration and modeling should be their next steps. They must also continually rebuild capabilities as district numbers increase and trained people leave the organization for employment elsewhere.

Uganda Bureau of Statistics (UBOS), Uganda

Mission of the Organization

UBOS is strikingly similar to the U.S. Census Bureau in its mission, projects, attitude toward data distribution, and relationship with government and public. Its primary mission is to conduct a national census roughly every ten years along with related mapping work and surveys, such as long-term household surveys. UBOS is “semi-autonomous” from government ministries to ensure independence.

Key Personnel

James Mubiru, Deputy Executive Director

Andrew Mukulu, Director, Population and Social Statistics (comparable to Chief, U.S. Census Bureau Population Division)

Bernard Muhwezi, Principal Geo-Information Officer

Charles Adriku, Senior Geo-Information Officer (non-administrative staff)

The above represent staff and three ascending levels of management. The team also met several other Geo-Information Officers and Godfrey Nabongo, a Communications Manager.

Geospatial Activities, Research, and Applications

The Population and Social Statistics division is the home of GIS at UBOS. Current geospatial activities include:

- Creating a national digital base map. Ugandan census statistics are built on the Enumeration Area (EA, averaging 100 households). Digital base maps at all other administrative areas already exist. The goal is a TIGER-type database but this requires extensive fieldwork for ground-truthing.
- Preparing for a 2010 census. This includes creation of maps at all administrative and statistical levels.
- Publishing geo-demographic atlases on population, poverty, and other topics.

UBOS uses the following definition of Uganda administrative divisions (ADMs):

ADM0 = nation, divided into four Statistical Divisions (non-administrative)

ADM1 = district, increased from 56 to at least 83 in recent years

ADM2 = county, 164 total

ADM3 = sub-county, 958 total (this is the level at which planning takes place.)

ADM4 = parish, 5238 total

ADM5 = village

Current Collaboration Efforts

UBOS has received funding and training from USAID, DFID, United Nations Population Fund (UNFPA), Statistics South Africa, Norway, Japan, and the EU. Ugandan censuses have historically depended on foreign funding. The U.S. Census Bureau International Population Center has trained several staff.

UBOS seeks future collaboration in the following areas:

- Keeping up with rapid technological changes. UBOS cannot afford the number software licenses it needs. UBOS owns a large building so physical infrastructure is not an issue.
- Training.
- Use of satellite images to map urban areas. UN Habitat funded a pilot study that worked well.
- Improvement in processes and products through discussion with other countries. For example, Mr. Mukulu chairs the East African Regional Census Committee.
- Establishing itself as a center of excellence for statistics in Africa. The goal is for UBOS to serve as a geospatial hub, or information repository for African census data, to improve data sharing and access. It is unclear how soon this could occur in practice, since UBOS has little Internet presence.

Capacity and Ability to Influence Decision-making

As in the U.S., UBOS is non-political. It does not seek political influence except to the extent needed to ensure the confidentiality of personal data and achieve its statistical mission. Also as in the U.S., UBOS has

defeated attempts by other ministries to access personal data, but all aggregated data are freely available to anyone, domestic or foreign.

The UBOS staff is proud of its success in enumerating controversial variables such as ethnicity and religion objectively. Their data on these topics are trusted by the public and government even when the results are contrary to what different groups want. As in the U.S., UBOS data are used by decision-makers and businesses. Thus, while UBOS is certainly capable of influencing decision-making, its influence comes through use of its data rather than any direct action, as is typical of statistical agencies.

Summary Findings

At the most local level, UBOS depends on the cooperation of local officials and the public for its mapping efforts. Village boundaries are delineated with the parish chiefs' cooperation. Public cooperation with census-taking is generally very good. However, it faces difficulties in less-secure areas of northern Uganda.

Demand for data is "enormous" and growing, for use in planning, elections, education planning, HIV service provision, distribution of mosquito nets, and business (e.g., cell phone tower placement). As in the United States, more inter-censal data are needed, but Uganda has nothing similar to the American Community Survey.

In common with other Ugandan agencies, UBOS faces an increased workload as Uganda increases the number of districts. Each time a district is split, UBOS must redistribute data to the new boundaries. Lower-level boundaries also change. The technical capacity of UBOS staff appears to be excellent, but both census projects and publications depend partly on foreign assistance.

Nile Basin Initiative (NBI), Uganda

Mission of the Organization²

NBI's mission is "to achieve sustainable socio-economic development through the equitable utilization of and benefit from the common Nile Basin water resources." The NBI seeks to develop the river in a cooperative manner, share substantial socioeconomic benefits, and promote regional peace and security. Cooperative water resources management is complex in any international river basin. In the Nile Basin, which is characterized by water scarcity, poverty, a long history of dispute and insecurity, and rapidly growing populations and demand for water, it is particularly difficult. The NBI started with a participatory process of dialogue among the riparian states that resulted in agreement on a shared vision to "achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources."

Key Personnel

Henriette Ndombe, Executive Director

Dr. Dan Temu and Dr. Hellen Natsu, NBI Socio-economic Branch

The NBI is a partnership of the riparian states of the Nile River through the Council of Ministers of Water Affairs of the Nile Basin states (Nile Council of Ministers, or Nile-COM). The Riparian States that participate in NBI are: Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania and Uganda. Eritrea currently participates in the NBI as an observer. Its key partners include aid agencies from Europe and Canada, as well as the UN Development Program (UNDP), UN Office for Project Services (UNOPS), the World Bank, and the Global Environment Fund.

Geospatial Activities, Research, and Applications

The NBI is carrying out a number of projects and activities that have clear geospatial components:

- The Water Resources Planning and Management (WRPM) Project, which is setting up a decision support system. Baseline study and needs assessment of the Water Policy have been conducted at national and regional level. Good practice and guidelines for water policy formulation and implementation were developed, and a regional training course on the IWRM focusing on the water policy was conducted.
- Effective knowledge management and information sharing among NBI programs that link public, private sector, stakeholders, and development partners, and have enhanced NBI and stakeholders abilities to communicate and share knowledge and information.
- NBI is carrying out the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) with projects in (i) Power Trade and Development and (ii) Natural Resources Management and Development. Detailed preparation on the ground has begun for three River Basin Management Projects, and the Fisheries Project on Lakes Albert and Edward. There are also on-going projects in agricultural production and eradication of water hyacinth.
- The NBI has finalized a study on watershed management dealing with trans-boundary analysis and public goods financing.

Current Collaboration Efforts

The team observed that NBI's extensive social capital resides with individuals within institutions in the region. One example was Mr. Temu's extensive personal networks. In fact, he connected the team with his childhood friend, Dr. Silas Lwakabamba, Rector of the National University of Rwanda. NBI collaborates with national "centers of excellence" and has carried out activities through agreements with public and private sector institutions.

Analytical, Data, Technical, and Infrastructure Issues

NBI faces serious issues regarding the transparency of data acquisition, information flow, and provision.

² Note that the much of the language in this section was taken directly from the www.nilebasin.org website.

Capacity and Ability to Influence Decision-Making

The founding principle of the NBI since its inception has been the incorporation of policy and decision makers from across the region. Each member country puts forward one institution to act as a center of excellence in a specific area for all of the NBI member countries.

Summary Findings

It is notable that the trajectory of development is similar to, yet deliberately slower, than another intergovernmental organization, the Inter-American Institute for Global Change Research. It appears that they have lessons that scientists can learn by studying their approach to engagement and consensus building.

GDEST team found that the socio-economic development center of excellence located in Entebbe, Uganda held the belief that the NBI could benefit through the linkage and or networking of the NBI to other activities within the region as well as internationally. NBI were quite interested in connecting with the Association of American Geographers.

The NBI center at Entebbe was also quite surprised to learn of existing GIS capabilities in Kampala at MUIENR, Makerere University as well as Urban Harvest and PRIME/West.

National University of Rwanda (NUR), Rwanda

Key Personnel

Professor Silas Lwakabamba, Rector³

Lwakabamba is a mechanical and power engineer with a B.Sc. and Ph.D. from the University of Leeds. He previously served in the nationalized utility company before becoming Rector of the University of Science and Technology in Kigali. He was appointed Rector of the National University of Rwanda (NUR) in 2004. Lwakabamba is Tanzanian with family ties to Rwanda; he is one of the many technocratic expatriates and/or experts from neighboring states who have joined President Kagame's progressive government.

Geospatial Activities, Research, and Applications

The rector believes a "picture is worth a thousand words," and thus sees a growing role for GIS and remote sensing products and analysis to bring policy initiatives to the decision-makers. He praised the NUR Center for Geographic Information Systems (NUR-CGIS) and Director Kurt Brassels' team, conveying his personal commitment to see the Center strengthened.

Lwakabamba also knows Alfred Watkins of the World Bank Office of Science, Technology and Innovation. Although he had not seen the final report on S&T and Innovation in Rwanda just published by Watkins' team, the Rector knew about its contents and sees a large role for the university and the NUR-CGIS in helping to foster progress, innovations in value chains, entrepreneurship and small businesses in the food, natural resource and other sectors examined in it.⁴

Analytical, Data, Technical, and Infrastructure Issues

Lwakabamba also has NUR in synch with the Vision 2020 for Rwanda and the complementary Policy on Science, Technology and Innovation published in 2006 by the Rwanda Ministry of Education, Science, Technology and Scientific Research headed by Dr. Romain Murenzi and with the support of the United Nations University Institute of Advanced Studies⁵. He noted that Rwanda has 30,000 students enrolled nationwide in 6 public and 12 private higher education institutions with 8,000 of that total at NUR in Butare. He also acknowledged that this is but a small fraction of the supply of educated young people that will be required to transform Rwanda, but believes the country is on the right track. He is a strong advocate of the strategy to pursue a knowledge economy, to add value to its natural resources and unique products and to lay the foundations for a larger service industry.

Capacity and Ability to Influence Decision-making

The rector is a leader in a well-integrated Rwandan scientific and engineering community that includes S&T Minister Murenzi and cabinet ministers whose organizations require S&T and engineering assets and are consumers of remote sensing and GIS data and analysis. He said that everyone has bought into Vision 2020 and highlighted the fact that the President runs a paperless cabinet, sending personal e-mails to all of his team and expecting them to respond when he does. Even the Parliament has computer screens at all seats and MPs use computers liberally.

Summary Findings

None provided.

³ The Rector was originally scheduled to meet with the E/S Team in Butare, but was called to high level meetings in Kigali the night before the team's planned visit to the University. Instead the team met with him on March 5th for breakfast

⁴ *The Role of Science, Technology and Innovation in Rwanda*, op. cit.

⁵ The Republic of Rwanda's Policy on Science, Technology and Innovation, Romain Murenzi, Mike Hughes, Lead Coordinators, Ministry of Science, Technology and Scientific Research, UN Institute of Advanced Studies, 2006.

Centre of Geographic Information Systems and Remote Sensing (CGIS-NUR), Rwanda

Mission of the Organization

To generate and disseminate high quality multidisciplinary knowledge and promote effective research, skills training and community service for national competitiveness and sustainable socio-economic development. The Vision 2020 initiative established GIS as a key tool to move Rwanda towards a science and technology based economy. As a “GIS Center of Excellence” CGIS provides GIS support to agriculture and infrastructure.

Key Personnel

Professor Silas Lwakabamba, Rector
 Professor Kurt E. Brassel Director (retired from U. of Zurich)
 Dr. Michele Adesir-Shcilling, Senior Lecturer
 Jean Pierre Hitimana, Head, Geo-IT Unit
 Deo R. Rutamu, Project Coordinator for Rwanda Development Gateway (RDGG)
 Nicole Ueberschaer, Technische Fachhochschule Berlin (1 year appointment)

Geospatial Activities, Research, and Applications

The Rwanda Development Gateway Group (RDGG) is a site for everything spatial for Rwanda and beyond. RDGG goal is to provide a spatial content to the Sub-Saharan Africa Country Gateways Web Portal and develop CGIS's capability as a regional outreach center in the fields of GIS and RS for sustainable development and poverty reduction issues.

CGIS has developed an introduction and advanced GIS and RS course, as well as short training courses in geospatial sciences. CGIS has trained 15 African Country Gateway Managers in GIS, RS, GPS and Web mapping. As the central clearinghouse, CGIS also inventories and classifies the national spatial database, acquires and collects data, and produces products.

The Coffee of the Thousand Hills project is an excellent example of GIS working to support decision-maker in government and agriculture. The model takes into account many spatial variables to break the county up into coffee sectors. The results will help guide decision-makers in developing Rwanda as a high quality coffee producer.

Current Collaboration Efforts

CGIS has a strong history of partnerships with the Dian Fosse Foundation. CGIS is an ESRI partner and has a strong connection with ESRI-Germany ESRI President Jack Dangermond provided GIS software to CGIS-NUR and secondary schools in Rwanda.

Analytical, Data, Technical, and Infrastructure Issues

CGIS-NUR can make a considerable contribution to establishing data policies and spatial data infrastructure. The relationship of the center to other institutions, such as Rwanda Information Technology Authority (RITA) and the Ministry of Lands, Environment, Forestry, Water, and Mines (MINITERE), may need to be clarified and its mandates reinforced as Rwanda moves forward in establishing data portals and dissemination channels.

CGIS-NUR also faces the challenge of retaining skilled Rwandan personnel in the wake of growing demand for geospatial science expertise. Several of the staff complained that their salaries were not equivalent to what they could receive elsewhere. Although the staff appeared to be highly motivated and dedicated to the center's objectives, such loyalty may not be sufficient to counteract the pull of higher incomes elsewhere.

Capacity and Ability to Influence Decision-making

CGIS-NUR has a relatively well-staffed and well-equipped facility to conduct analyses. Their maintenance of the Rwanda Development Gateway, places it in the center of information exchange on development

issues. The center remains highly dependent upon expatriates for management and leadership. This may ultimately be a constraint to its authority and access to key decision-makers.

Summary Findings

The Center faces issues with facilities, staff, and curriculum.

- The 1994 genocide decimated faculty and staff. The university is trying to rebuild capacity.
- Being in Butare isolates the facility from the main campus of NUR. Poor Internet connectivity between the two campuses exacerbates faculty and student isolation.
- CGIS-NUR does not offer a master's program in GIS/RS although this is planned for 2010.
- The lack of funds makes it difficult to attract qualified staff to meet CGIS-NUR.

Rwanda requires prudent management of its natural resources and CGIS can be an invaluable source of information for this purpose. CGIS is at a crucial point in developing as a higher learning institution. Although the center has government policy support, that support has not extended to provide sufficient funds to acquire the personnel to take it to the "next level" of research and development. CGIS could benefit from leveraging the partnership with ESRI and past relationships with the Dian Fossey Foundation to establish funded research positions.

Ministry of Lands, Environment, Forestry, Water, and Mines (MINITERE), Rwanda

Mission of the Organization

The Ministry of Lands, Environment, Forestry, Water, and Mines (MINITERE) is responsible for the conservation of the natural environment, for land allocation in resettlement areas, and for formulating proposals for land tenure policies and legislation.

Key Personnel

Patricia Hajabakiga, Minister

Mr. Eugene Rurangwa, Director of Lands & Land Registration

Current Collaboration Efforts

The ministry collaborates with a number of UN organizations in almost all fields of responsibility that fall under the Ministry. The ministry is also collaborating with a number of NGOs, particularly in biodiversity conservation.

Geospatial Activities, Research, and Applications

MINITERE is one of the most active supporters and largest consumers of GIS data and analytical products in Rwanda. Land tenure affairs have been devolved to the district councils, and responsibility for environmental and natural resources is delegated to various line ministries. The overall role MINITERE is to manage the National Strategy for the Environment implementation process, and to ensure that technical ministries act in compliance with the government's environment conservation policy. The ministry is structured into five departments: (1) Environmental Protection; (2) Planning; (3) Lands; (4) Settlement; and (5) General Services. The Department of Environmental Protection has a staff of six professionals divided into three divisions: Environmental Policy and Planning, Monitoring and Evaluation, and Environmental Impact Assessments. No ministry office is envisaged at provincial level.

MINITERE is responsible for implementing several international environment protocols. As such, it has a wide responsibility for providing monitoring and assessment of environmental conditions and protocol compliance.

Minister Hajabakiga mentioned the completion of a prototype GIS project on forest cover and human development at the district level.

Analytical, Data, Technical, and Infrastructure Issues

The ministry may lead government-wide efforts to consolidate and manage GIS data. The minister said the president's mid-February 2008 cabinet retreat received well her push to organize government-wide data harmonization and centralization. However, this issue remains undecided and debate continues for both centralized and decentralized approaches.

Capacity and Ability to Influence Decision-making

Land reform and land tenure issues are central to establishing and maintaining stability in Rwanda. As such, this ministry is central to policy development and decision-making on future development trends in the country.

Summary Findings

Minster Hajabakiga was very interested to hear about U.S. Census Bureau standards and practices and asked to follow up with team member Joshua Comenetz.

Research, Science and Technology, Office of the President of Rwanda & Rwanda Information Technology Agency (RITA)

Mission of the Organization

RITA advises S&T Minister Romain Murenzi and oversees implementation of the 2006 Rwanda Policy on S&T and Innovation. As such, it could be said that he and the ministry at the President's Office (MINIPRESIREP) has a main line in-road to influence decision-making, albeit with very limited capacity.

Key Personnel

Romain Murenzi, Minister of Science and Technology

Michael Hughes, Advisor

RITA has a staff of 80 people, dedicated to developing an information portal, encouraging metadata collection across ministries, and facilitating related training.

Current Collaboration Efforts

The STI Policy was developed with support from the Institute of Advanced Studies, UN University, and this relationship continues. DIFD is developing a legal and regulatory framework for the STI policy. The World Bank also is interested in RITA's work. RITA hosted two Embassy Science Fellows in 2007, Craig Haas (EPA), who advised on biofuels standards and regulations issues, and Toral Patel-Weynand (USGS), who helped prepare an inventory of Rwandan biodiversity assets.

Analytical, Data, Technical, and Infrastructure Issues

Several key issues were identified during the meeting: (1) who controls metadata (2) who is responsible for setting standards (3) how Rwanda can meet its workforce development requirements.

Mr. Hughes noted that ICT and Geo-information are the subjects of sections 5.9 and 5.10, respectively, in the STI Policy. He said that President Kagame highlighted the central importance of these assets in speeches to the African Union in January 2007 and an African ICT conference in May. Mr. Hughes added that standards for geo-data and delineation of responsibilities are still under review in the government Strategic Plan for 2008. RITA could possibly surface as the lead agency, but there is clear pressure from individual ministries to be responsible for their own data sets. Hughes also acknowledged that NUR/CGIS is the recognized center of excellence for GIS in Rwanda and that the Centre and the University should figure greatly in the strategic plan. He said that an Economic Development and Poverty Reduction Strategy being prepared will also highlight the role of ICT and GIS/RS assets.

Two Team West members recommended that the final policy should make donors responsible to meet these standards and to deliver all data associated with particular projects. All agreed data sharing and access to data for all stakeholders should be core precepts for the national policy. In that context, Ms. Lance said that SERVIR is opening an African center and that training and guidance for metadata practices will be included in it; a SERVIR conference is scheduled later in 2008 in Rwanda. Mr. Richardson observed that the potential for job creation in a variety of service areas would be facilitated by open access to such data. He offered free memberships to enter AAG portals for resources and distance-learning programs to help facilitate training.

Capacity and Ability to Influence Decision-making

RITA is well-situated to influence national policy regarding geospatial science and technology because it is housed in the Office of the Presidency. However, given the range of IT issues and opportunities, RITA must embrace the importance of geospatial science and technology at a par with other information and science technologies that the government of Rwanda sees as fueling its development.

Summary Findings

Opportunities for U.S. Collaboration and Support:

- SERVIR for training and meta-data; upcoming conference in Rwanda in April to encourage formation of regional geo-portal;

- AAG membership and human capacity-building follow-up;
- New Embassy Science Fellows – tasks to be defined by Mr. Hughes;
- Possible Fulbright Senior Specialist;
- USAID programs to agriculture, e.g., soil mapping, watershed management.

Green Belt Movement (GBM), Kenya

Mission of the Organization

The Green Belt Movement is a high profile civil society organization, based in Kenya, advocating for human rights and supporting good governance and peaceful democratic change through the protection of the environment. Its mission is to empower communities worldwide to protect the environment and to promote good governance and cultures of peace.

The Green Belt Movement (GBM) was started in 1977 by Dr. Wangari Maathai, the first African woman and the first environmentalist to receive the Nobel Peace Prize (in 2004). What began as a grassroots tree planting program to address the challenges of deforestation, soil erosion and lack of water has now acquired a broader organizational focus for empowering women throughout the developing world. The Green Belt Movement sees women as agents of change for in Kenya and around the world for sustainable management of scarce resources such as water, equitable economic development, good political governance, and for achieving peace.

Background

To date, more than 40 million trees have been planted across Africa, designed to reduce soil erosion, protect watersheds, restore biodiversity-rich indigenous forests, help local communities become more sustainable. The organization is now in the process of going international, and has as a goal the planting of one billion trees worldwide.

Opportunities for Collaboration

A GDEST meeting was held in Nairobi, Kenya, with Mr. Peter Ndunda of the Green Belt Movement on March 6, 2008. Mr. Ndunda is a very talented young Kenyan, who has considerable past experience working with US-based non-profits and private sector companies, and a promising career in geospatial technologies in Africa. He participated in the Association of American Geographers (AAG) My Community, Our Earth (MyCOE): Geographic Learning for Sustainable Development) program in 2002, and was one of four international students who received sponsorship to receive an ESRI internship. He went on to earn a MS Degree from the University of Redlands in GIS, and later worked as a geo-information consultant at the World Bank in Washington, DC, where he met Dr. Wangari Maathai. Upon his return to Kenya, Maathai recruited him to work at the Greenbelt Movement offices in Nairobi, where he has worked to develop the organization's GIS capacity for the past two years.

Given the high international profile of Nobel Prize recipient Dr. Maathai's Green Belt Movement, and Mr. Peter Ndunda's talent and likely emergence as a force in geospatial science in Kenya and more broadly across Africa in the future, closer ties might be established with the organization. Mr. Ndunda has expressed an interest in participating in future MyCOE projects, both in Africa and internationally. He has also expressed a desire to study for a PhD in geography in the United States in the future. The AAG could help facilitate both of these collaborations.

Summary Findings

None provided.

Climate Prediction and Applications Centre (ICPAC) of IGAD (Intergovernmental Authority on Development), Kenya

Mission of the Organization

The mission of ICPAC is to foster sub-regional and national capacity for climate information, prediction products and services, early warning, and related applications for sustainable development in the IGAD Sub-Region.

Key Personnel

Professor Laban A. Ogallo, a chapter lead with the Intergovernmental Panel on Climate Change, is Director of IGAD Climate Prediction and Application Centre.

Geospatial Activities, Research, and Applications

Dr. Ogallo described his concern for a changing climatological environment in Kenya and its potential to disrupt an agricultural industry already stressed due to drought. He described an agricultural community losing young people to the city with the remaining population predominately illiterate. Reaching that population with internet or other geospatial science and technology would be difficult in the short term, though using a radio internet system (RaInt) would be a positive approach. He noted that 90% of the older generation is illiterate and the literate portion read and write at only the 8th grade level. He noted that data and information sharing in this environment is difficult. He also noted that 10% of the general population is college educated.

With climate change increasing the risk of drought and agricultural uncertainty there is the potential for climate related conflict. He pointed out that there is a need to develop a strong basis for geospatial analysis, geospatial resources must be assessed and opportunities and challenges must be addressed to respond to environmental changes and population pressures. Dr. Ogallo said that methods must be developed to provide geospatial information to the uneducated rural population in a way they could use the data and that education of the future population is important. An improved level of education would be needed for people to be able to respond to the pressures of a changing climate regardless of how it changed.

ICPAC conducts numerous activities that use geospatial science and technologies. In one way or another they are used on all programs. These programs include: Computer Services and Data Management; Climate Diagnostics, Prediction and Climatology; Climate Applications; Documentation, Research and Development; End User Liaison; and Operational Activities.

Current Collaboration Efforts

ICPAC collaborates globally with the World Meteorological Organization, United Nations Development Program, International Research Institute for Climate and Society, Southern African Development Community Drought Monitoring Centre, African Centre of Meteorological Application for Development, the U.S. Geological Survey, U.S. National Oceanic and Atmospheric Administration, U.S. National Aeronautics and Space Administration, Australian Government Bureau of Meteorology, National Meteorological Agency of Ethiopia, Sudan Meteorological Authority, Tanzania Meteorological Agency, Uganda Department of Meteorology, and Kenya Meteorological Department. ICPAC can be considered a very well connected organization and an important contributor to African the meteorological, climatological, and development community.

Analytical, Data, Technical Infrastructure Issues

Their remote sensing capabilities are quite high and are central to many of the scientific activities of the programs. Use is made of U.S. National Oceanic and Atmospheric Administration, U.S. Geological Survey, and U.S. National Aeronautics and Space Administration satellite data. Geographic information systems (GIS) technology and science are used, but need to be enhanced. For both remote sensing and GIS, the establishment of databases is considered an important priority. Improved communication is critical. The lack of deep penetration of the Internet and the limited bandwidth capacity hamper the potential for using the analysis to greatly improve the living conditions of the population while conserving and enhancing natural resources.

Capacity and Ability to Influence Decision-making

ICPAC produces numerous climatological products that are used by regional partners, the national governments of its participant organizations, and international fora such as the Intergovernmental Panel on Climate Change. Among the current valuable outputs is an assessment of the climate and vulnerability generated by the environment, and the current and potential socioeconomic conditions that can have positive or negative effects. These are based on the observed and projected climate anomalies. The assessments are made on decadal (ten day time period), monthly, and seasonal basis. These assessments are disseminated to all national meteorological and hydrological services of the participating countries. They serve as early warning information to a variety of users such as policy makers, planners, health, energy, agricultural, and water resource sectors, farmers, research institutions as well as others.

While the information is provided to the appropriate organizations and is often used, additional benefits could be derived if governments focused more of their efforts on agricultural and other sector response to the information. Also, improved education of the general population might help improve the effectiveness of the information.

Summary Findings

ICPAC is a very accomplished organization with many activities, including its establishment of a climate data bank that is consistently updated, uninterrupted timely delivery of climate warning information, and capacity building workshops. With proper resources, it could have the opportunity to expand educational opportunities by training trainers and helping identify opportunities to raise the knowledge level of the general population in its area of interest. This is perhaps both its greatest challenge and opportunity—to find a way to better use its excellent information to help the general populations of the region of interest to improve their agricultural, water management and other practices and make sustainable impacts in living conditions and standards. Finding ways to use geospatial science and technology to make inroads this area is a major challenge.

Regional Center for Mapping of Resources for Development (RCMRD) and United Nations Environment Program, Kenya

The Site Visit Team met with representatives from a number of organizations in Kenya at a hotel near the airport for approximately 3 hours. The organizations had different missions and included government organizations, international bodies, and non-government organizations.

Regional Centre for Mapping of Resources for Development (RCMRD)

Dr. Wilber Ottichilo made introductory remarks for his organization and turned the rest of the discussion over to Dr. Tesfaye Korme. Dr. Ottichilo was most interested in the use of geographic information science and technology for sustainable development.

Dr Korme, a geologist who teaches geodynamics and modeling, is concerned with surface and groundwater sustainability, both quantity and quality. He pointed out that cut flowers, one of the most important economic export industries in Kenya and Ethiopia, is highly polluting but also creates many jobs. He also pointed out that there are many other environmental issues of concern to the region as well. He mentioned the eutrophication of Lake Victoria and the landslide program run at his institution (landslides have increased due to the land use practices in hilly areas) as two more examples of problems in the region. He said that his organization needs assistance with the LandInfo system and with urban mapping in places like southern Sudan. One possible link is with USGS Landslide Program.

United Nations Environment Program

Mr. Jess Gunboat, project manager for the Data Exchange Platform for the Horn of Africa, explained that there is GIS capacity locally in Nairobi, but that it is important to expand the use of GIS and remote sensing, and the acquisition of base cartographic data. They must backstop local or even larger groups as those groups do not have the resources or often expertise to conduct their own geographic information science and technology work themselves.

Mr. Peter Girth, Director of the UNEP Division of Early Warning and Assessment, and Mick Wilson, a UNEP geospatial analyst, said that it is important to researchers to be able to access large volumes of data and that their group can help make that happen. People need high level products to conduct analysis and to make decisions, and transmitting that information to those who need it can be difficult. An ongoing monitoring effort is needed for environmental purposes and issues related to sustainable development.

Summary Findings

Due to the presence of a number of international organizations with scientific capabilities in Nairobi, Kenya the environment is fairly sophisticated with regards to geospatial information science and technology. The organizations are either part of donor groups or receive funding from donors, either government or non-government. If external funding were to decrease, there could be a sudden decline in the sophistication of the geospatial community in Nairobi. There exists a great need to develop an understanding of how to make these scientific communities sustainable at the appropriate level.

Harry Oppenheimer Okavango Research Center (HOORC), University of Botswana, Botswana

Mission of the Organization⁶

HOORC is a center for the study and conservation of one of the world's largest and most intact wetland ecosystem, the Okavango Delta, as well as other wetlands, river basins and watersheds in southern Africa. Multi-disciplinary in approach, HOORC initiates, coordinates and promotes research and assists with environmental monitoring. It aims to develop and implement educational strategies for the sustainable use of resources in order to promote the long-term conservation of the Okavango and other regional wetlands.

Key Personnel

Prof. Sue Ringrose
 Prof. Lars Ramberg
 Dr. Cornelius Van der Post
 Dr. Piotr Wolksi
 Mr. Patrick Mwenya.

HOORC has 25 academic staff and 35 support staff.

Geospatial Activities, Research, and Applications

HOORC is located near Maun, the primary city in northwestern Botswana, on the fringe of the Okavango. It specializes in natural resource management research, with a primary focus on influencing policy makers on the region's most pressing environmental issues.

HOORC has a strong tradition of research involving the use of geospatial data. Currently there are 69 listed projects, each of which has a geospatial component. In addition to basic research, there is a strong thrust in conducting applied research, the results of which are to inform management practices and policies involving decision makers.

Current Collaboration Efforts

HOORC has over 50 research and development projects in progress in a wide range of scientific fields, many in collaboration with international partners. HOORC has developed an extensive network of partnerships with research institutions. It has strong links with NASA and utilizes its services for satellite imagery. Major collaborations include:

- Hydrology and Ecology of the Okavango Delta Floodplains, in collaboration with University of Oslo and Anhalt University;
- Ecological Diversity at SAFARI 2000 Sites, in collaboration with the University of Virginia;
- Satellite Imagery of Delta Topography, Ecology and Habitats, in collaboration with the University of Texas and NASA;
- Floodplain Vegetation Dynamics, in collaboration with the University of Pretoria;
- The Impact of Invasive Grass Species, in collaboration with the Netherlands Institute of Ecology, the Centre of Ecology and Hydrology and Rhodes University (South Africa);
- The Sustainable Management of Southern African Savannas, in collaboration with Kings College (London), IUCN (Harare), and the University of Durban Westville (South Africa);
- Community Based Wildlife Management, in collaboration with the University of Zimbabwe;
- The Development of an Integrated Management Plan for the Okavango Delta, in collaboration with IUCN and the Ramsar Bureau;
- Water and Ecosystem in Regional Development, in collaboration with Linkoping University (Sweden), University of Sussex, University of Pretoria and the Desert Research Foundation (Namibia);
- Preservation of the Peter Smith Herbarium, in collaboration with the National Botanical Institute (South Africa);
- Herbivores and Habitat Utilization in the Okavango Delta (in collaboration with the University of Wageningen (the Netherlands) and the University of Bristol (Great Britain);
- A summer school with the University of Florida; and

⁶ As taken from <http://www.orc.ub.bw/>

- Participation in ELTOSA, (Environmental Long-Term Observatories of southern Africa), a network of southern African countries embarking on time-series environmental research and monitoring programs delivering time-series datasets and
- Membership in the international Global Wetland Consortium.

Analytical, Data, Technical, and Infrastructure Issues

HOORC is part of the University of Botswana and has a library, a herbarium and laboratories for biology, chemistry and GIS, and a tented camp for visiting students and researchers. Staff at the center is capable but under-resourced. The country has limited expertise in geospatial science--resulting in government and the private sector competing for expertise present either at HOORC or at the main campus of the University of Botswana. Such a demand also makes it difficult to retain capable people with in academia. The GIS brain drain makes it difficult for the University and the HOORC to train additional qualified researchers in science.

Acquisition of higher resolution remotely sensed imagery for the Okavango delta region is the main data issue for the HOORC. The center needs remotely sensed information for topographic mapping activities. While they have access to the 90m resolution SRTM data, HOORC staff expressed a strong desire to acquire the highest resolution data possible that will help center staff resolve issues with the hydrology of the Delta.

HOORC staff was concerned about the non-interoperability of data sets and operating systems among the different governmental and non-governmental organizations. The lack of institutional memory regarding these data sets further complicates matters and, of course, is related to the demand from the private sector for qualified geospatial science and analysis professionals. This leads to inadequate oversight and maintenance of data archives and even lack of knowledge as to their location.

Capacity and Ability to Influence Decision-making

HOORC staff is fairly well positioned to produce information to influence decision makers by virtue of their applied research projects. It was not clear whether they have been successful at being able to do so, however.

Summary Findings

There is a need for remotely sensed information to help with the center's topographic mapping activities. While they have access to the 90m resolution SRTM data, they need to acquire the highest resolution data possible to help staff resolve issues with the hydrology of the Delta.

HOORC offers an excellent platform for regional collaboration and research, but it is constrained by space and a high demand on its resources. Further, HOORC is constrained by its dependence upon expatriate scientists and may be strengthened through the introduction of more expertise from neighboring states, such as Zambia, Zimbabwe and eastern African countries.

Department of Geological Survey (DGS), Botswana

Mission of Organization

DGS's mission is to advance knowledge on the earth resources of Botswana and to advise government and the public on their sustainable utilization for the benefit of all by acquiring, archiving, interpreting and disseminating geoscience information on Botswana. DGS seeks (1) to enable the speedy discovery and development of mineral and water resources for sustained economic growth, health and safety and (2) to support sustainable land resources utilization and the use of best practices for environmental upkeep and protection. These activities are all technically backstopped with acquisition, archival, interpretative and disseminating activities.

Key Personnel

- Tiyapo Hudson Ngwisanyi, Principal Geophysicist, Acting Director of the Department of Geological
- Ngonidzashe Isaac Tobani, Environmental Engineer and Hydrogeologist
- Gomotsang Tshoso, Principal Geophysicist
- Dikabo Mogopadi, Chemistry Laboratory
- Mosaboswa Hilary Koketso, Principal Geophysicist
- Lekgoa Lesole, Sr. GIS Officer, GIS and RS
- Regina Mokgosi, Cartography Section
- Milton Keeletsang, Borehole Data Management
- Shadrack Mogapi, Cartography Section
- Magowe Magowe, Principal Hydrogeologist

DGS has approximately 300 employees of which 70 slots are designated for scientists. Some of the slots are not filled. The team met with professionals in the disciplines of geophysics, geology, cartography, information technology, and hydrology.

Geospatial Activities, Research, and Applications

Funding is available for projects, but there is insufficient capacity within the organization to complete many of them. DGS is planning the following projects:

- Identification, assessment and exploitation of industrial minerals and other commodities;
- Assessment for mineral potential of mafic, ultramafic and granitic complexes;
- Assessment of kimberlitic diamond exploration techniques;
- National geotechnical investigations;
- Seismicity studies of Botswana;
- Regional groundwater monitoring (quality and quantity);
- Delineation of aquifers; and
- Assessment of regional impacts of mine dewatering and water supply well field abstractions.

Current Collaboration Efforts

DGS has conducted collaboration efforts with government, private industry, and academic experts in the past. It continues to do so and would like to do so in the future as well. Currently they work with AfricaArray to enhance capabilities (in the area of seismic studies, interpretation of seismic data) and capacity (in terms of the number of personnel). AfricaArray is led by the Pennsylvania State University, the University of Witwatersrand, and the South African Council for Geoscience with support from USGS. Representatives of Penn State have briefed U.S. Department of State's Bureau of Oceans, Environment, and Science and others on the activities of their project.

Currently DGS is collaborating with other government agencies on their National Spatial Data Infrastructure (NSDI) but the effort is moving forward slowly. While there is a potential to collaborate with domestic academia, no formal links exist. DGS would like better connections with the University of Botswana, especially with engineering and environmental sciences undergraduates early in their academic careers to build both capability and sorely needed capacity (internships, fellowships, post docs, and other creative means should be explored for this purpose).

DGS would like to connect with U.S. experts in historical synthesis of geospatial data (mainly universities and Library of Congress). They also expressed an interest in collaborating with U.S. experts on a number of their analytical, data, technical, and infrastructure issues.

Analytical, Data, Technical, and Infrastructure Issues

Assistance is needed with information infrastructure activities, particularly with SDI management, data standards, archival techniques and metadata. They also need assistance obtaining or producing some fundamental data (aquifer delineation, demand analysis, aquifer sustainability). DGS noted that some agencies that are cooperating in the development of the NSDI, but are under pressure to absorb both the cost of production of the data and the cost of reproduction and distribution. DGS personnel noted that some data from their agency and others participating in the NSDI cannot be shared because it is proprietary. DGS holds the copyright for its own data.

The successful implementation of the mission is in jeopardy due to a score of issues. The amount of research conducted by DGS is declining, with only few projects being done in the last 5 years. There is also incapacitation due to a loss of staff and there have been no new mineral discoveries since 1990. Furthermore, the geological and geochemical information content of most reports by companies is minimal and there is hardly any information on the Internet. Also the paucity of historical geological information may become a constraint in making future discoveries, especially in diamond exploration. Construction, environmental issues and management are also of concern.

Capacity and Ability to Influence Decision-making

DGS is unable to meet their mission in a number of areas and are unable to provide the information needed to influence decision makers. DGS believes it would have the ability to influence decision making if it were adequately funded and if salaries were competitive with private industry.

Summary Findings

DGS has difficulty retaining personnel due to the low pay of government positions and if the trend continues, their ability to meet their mission will continue to erode. DGS was once one of the best geological surveys in the world but has lost both capability and capacity through attrition. Botswana needs geologic maps but DGS has not produced a map in the past 5 years. Without mapping capacity, DGS's charge to study mineral resources is thwarted. No economic mineral discoveries have been made since 1990. Their responsibility to monitor industry is limited as well. Most companies report the minimum of information needed for monitoring, yet DGS is too understaffed to completely analyze it. They also must contract for mapping and other scientific activities as well as for the quality assurance and quality control of that work.

DGS has done gap analysis of personnel needs to establish the number of people and the types of skills they need. The organization must identify who will train the personnel who are hired as college graduates. Typically, college graduates have background knowledge and general scientific expertise, but need specialized training to meet government demands. Internships can provide opportunities for university students to gain real world experience on government research projects, but they may consume more effort in training time than their actual contribution warrants.

DGS personnel indicated there are a number of additional needs. They believed that working with international scientists would help them develop data and also improve their skills, capabilities and capacity. It is important that DGS work through its government structure to communicate with the U.S. Embassy and USAID to make its needs for expertise known. Skilled participants could be used from programs like Fulbright, Embassy Fellows, and others.

NSDI is in its infancy and additional work is needed among agencies to ensure the data are interoperable. DGS has shifted much of its effort from mapping to analysis, but needs to once again increase mapping capacity. Part of its analysis load could perhaps be shared with universities.

Collaborating with other mapping agencies, both within and outside Botswana might help to improve their mapping efforts within DGS. Their responsibilities could be improved by connecting DGS with practitioners in the U.S. specializing in permitting and regulatory activities related to extractive industries. Exchanging technical knowledge might be of value to both parties and it would be valuable to share background and lessons learned regarding cooperation with non-government organizations (NGOs).

South African Development Community (SADC) Regional Remote Sensing Unit (RRSU), Botswana

Mission of Organization

RRSU serves the needs of SADC's 14 member states and is an application center for remote sensing and GIS technologies focused on early warning for food security, natural resources management and disaster management.

Key Personnel

Dr. Kennedy Masamvu, Project Coordinator
Mrs. D. Nyamhanza, Senior Database Management Specialist
Mr. B. Siwela, GIS Specialist
Mr. T. Madagzire, Geo-information Scientist (USGS/FEWSNET)

Geospatial Activities, Research, and Applications

The RRSU has several operational activities: (1) RRSU monitors crops, vegetation and weather developments during the crop growing period using satellite images (MODIS/NDVI), and GIS techniques. It produces growing season status reports, ten-day agro-meteorological reports, significant weather reports such as cyclone developments, and flood/drought reports. (2) RRSU maintains a database of satellite images, maps and associated data for distribution. RRSU maintains a website with access to seasonal reports, training and working papers, forecasts and imagery access. (3) RRSU trains agro-meteorologists in the use of satellite imagery products and GIS for early warning for food security.

Current Collaboration Efforts

The RRSU activities are associated with national meteorological departments, early warning units, and disaster management units. In addition, the RRSU maintains working relationships with the International Research Institute for Climate and Society, the UN World Food Program, and the UN Food and Agriculture Organization.

The RRSU collaborates with FEWSNET and the European Space Agency Global Monitoring for Food Security (GMFS). Collaboration with the GMFS focuses on the consolidation and support for regional information and early warning systems on food and provides products that will help answer critical questions of the food security early warning community. This collaboration includes provision of field data from the International Maize and Wheat Improvement Center (CIMMYT).

FEWSNET maintains a presence in the RRSU office through a USGS specialist who coordinates with the overall FEWSNET program, providing periodic reports and analyses which are developed in collaboration with the various regional and national southern African institutions.

Capacity and Ability to Influence Decision-making

Key constraints include time constraints of technical staff to document and post data. Although the RRSU has a mandate to address biodiversity and natural resource data, much of it remains to be captured, particularly that of the International Union for Conservation of Nature (IUCN), who maintain an office in Harare.

Summary Findings

The RRSU is a relatively small office with limited funding. This is further exacerbated by its recent move from Harare, Zimbabwe to Gaborone, Botswana as part of a SADC centralization effort. Various geospatial information units within the Food, Agriculture and Natural Resources unit lack coordination-- the Water Management unit operates a GIS just one floor down and has little interaction with the RRSU.

Use of the RRSU analytical products is limited due to low capacity within the various directorates and organs of SADC as well as its national constituencies.

Botswana Institute for Development Policy Analysis (BIDPA), Botswana

Mission of the Organization

BIDPA conducts and publishes research on development: livestock and agriculture, HIV, poverty, housing, and governance.

Key Personnel

Dr. T.J. Agiobenebo, former University of Botswana political science professor
Dr. Joel Sentsho
Dr. Tebogo Seleka
Dr. N.H. Fidzani, executive director

All of the above are economists and no geographers or regional economists are on staff. The total number of research staff is 20.

Geospatial Activities, Research, and Applications

BIDPA does not use remote sensing or GIS but understands the value of geospatial techniques and is aware of their use in the Geological Survey and University of Botswana. BIDPA staff believes that GIS tools would be valuable for studies of disaster relief, the mining sector, and other areas that have a spatial component.

Current Collaboration Efforts

Half of BIDPA's funding comes from the government. African capacity building foundations provide 17.5 percent of the institute's funding and the balance comes from consulting jobs, primarily from other government agencies. Some work has been funded by the EU, African Development Bank, and DFID.

Capacity and Ability to Influence Decision-making

BIDPA has a major influence on decision-making, both through its reports and through its training activities. Numerous topics are covered in their paper brochure but staff had difficulty explaining examples of actual projects when asked during the meeting with the GDEST team.

Summary Findings

BIDPA remains interested in geospatial applications as they relate to national planning efforts, but admit that they have not cultivated this expertise, largely as a result of having a strong neo-classical economics orientation.

As in the U.S. Government, reports must go through an extensive approval process before release. This limits the number of projects that can be undertaken concurrently. Published reports are freely available but data may be confidential and require Ministry approval to access.

National AIDS Coordinating Authority (NACA), Botswana

Mission of the Organization

NACA manages government HIV-related programs for the It gathers data on infected populations, creates population projections, and works to match the geographical distribution of resources (anti-retroviral drug distribution, clinics) with needs.

Key Personnel

Dr. Boga Fidzani (brother of Dr. N.H. Fidzani, director of BIDPA)
Wayne Gill, Monitoring and Evaluation section, detailed from UNAIDS
Kent Berger, GIS consultant, formerly in Malawi (was not present)

Geospatial Activities, Research, and Applications

NACA has created its own data-collection procedures without a functioning GIS system in any of the existing health districts. NACA is using FAO mapping software to map orphans. NACA's goal is to have a GIS-based system into which staff could input new data to automatically update national maps. Mr. Gill appears to be pushing this initiative as hard as he can, with support from his supervisor Dr. Fidzani.

Current Collaboration Efforts

NACA seeks future collaboration in three areas: training, data sharing, and applications. In training, Mr. Gill talked about collaboration with Mr. Nate Heard of the U.S. State Department Humanitarian Information Unit. On data sharing, NACA wants to share both HIV data and their population projection methods incorporating HIV data with the UN and U.S. Census Bureau. NACA GIS collaboration is just beginning.

Capacity and Ability to Influence Decision-making

NACA has evidently influenced decision-making on health policy, and gained government support, as shown by Botswana's success in providing antiretroviral therapy to 90 percent of the infected population. Further influence will come through adoption of GIS methods to map areas where there is a mismatch between HIV infection numbers and clinic locations

Summary Findings

Botswana has not digitized its census enumeration areas (comparable to tracts in the U.S.), so digital data only link to ten provinces or 27 health districts. Finer-scale mapping is needed to show geographic variation in infection and access or lack of access to clinics or drug distribution points.

NACA is in the office of the president and is currently in "emergency mode," both of which allow better access to data than otherwise. However, other government agencies are slow in sharing necessary information. The government lacks a geospatial understanding. For the ongoing Botswana AIDS Impact Survey, Gill attempted to use GPS to map all relevant sites (clinics, schools, etc.) but met with high-level government opposition. NACA lacks sufficient GIS-conversant staff. A recently-hired consultant (Mr. Berger) is the one of the most knowledgeable persons in the country according to staff, but is not a Botswanan. On the positive side, funding does not appear to be an issue since NACA is supported by diamond revenues.

Ministry of Environment, Wildlife and Tourism, Botswana

Mission of the Organization

This is a relatively new Ministry formed in 2002 by incorporating relevant sections of other departments and units from across the government. The overall responsibility of the Ministry of Environment, Wildlife and Tourism is to enhance the environment policy and management in forestry, meteorological services, tourism development and promotion, and conservation of wildlife.

The following governmental authorities are also overseen by the Ministry, in conjunction with other organizations with portfolio responsibilities related to them:

- Department of Forestry and Range Resources
- Botswana Wildlife Training Institute
- National Conservation Strategy Board
- Tourism Board
- Botswana Power Corporation
- Water Apportionment Board
- Water Utilities Corporation

Key Personnel

Dr. Lucas P. Gakale, Permanent Secretary of the Ministry of Environment, Wildlife and Tourism

Mr. Ephraim Mosimanyana, Dept. Director, Forestry and Range Resources

Mr. Stevie Monna, Dept. Director, Environmental Affairs

This meeting was a follow up to a discussion between the Permanent Secretary and Douglas Richardson on March 9, 2008.

Dr. Gakale is the senior civil servant and the ministry's chief executive officer. He manages all ministry affairs, under the direction of the Minister. Dr Gakale had an internship with the Botswana Ministry of Agriculture, and later in his career engaged in educational exchanges with several universities in the United States, including University of Nebraska, Colorado State, Kansas State, Mississippi, and Texas A&M. He is highly knowledgeable, and appears to be a committed and effective executive of the Ministry.

Mr. Monna is a dynamic and knowledgeable young man, who understands geospatial technology applications and had previously met Robert Swap in conjunction with the planning of the Southern African Regional Science Initiative – SAFARI 2000 (which was largely sponsored by NASA as well as in small part by NSF) during the 1998-2002 timeframe.

After the meeting, the team sent a letter (via the U.S. Embassy in Gaborone) to Dr. Gakale, inviting him or one of his senior staff to attend the GDEST Africa Conference in Cape Town on March 17-19, 2008. Subsequent to that invitation, Mr. Mosimanyana attended the Cape Town conference.

Geospatial Activities, Research, and Applications

The Ministry of Environment, Wildlife and Tourism uses geospatial data for forest inventories, range management, wildlife inventories, and fire monitoring. Additionally, Geospatial data is used for determining land degradation and desertification. Ministry also plans to develop a national GIS based Environmental Information and Management System (EIMS). The goal is to use EIMS archived data to determine trends to inform policy and decision-makers at the local and national levels.

Current Collaboration Efforts

The ministry staff collaborates with the University of Botswana faculty in Environmental Sciences, mainly in the form of consultancies. This is also the case with the Harry Oppenheimer Okavango Research Center located in Maun, which was contracted to produce the Okavango Development Plan.

Collaboration with other ongoing and proposed GIS initiatives throughout the government, and the pooling of resources and skills across ministries would expedite the implementation of the EIMS, if such coordination could be achieved. This interaction across agencies would be logical, as EIMS would provide access to data and information resources for many other governmental areas of focus, including agriculture, disaster

response, water, mining, and economic development, among others. Opportunities for collaboration with U.S. public and private entities in the development of the EIMS appear to be significant.

The Permanent Secretary and his Directors rely heavily upon local and external consultants to help address needs caused by insufficient staffing. While ministry staff are capable additional expertise is needed in the areas of developing rapid firefighting capabilities for remote fires, resource accounting/inventories, geospatial data management and metadata best practices. Challenges also continue to exist in the area of collaboration and coordination among multiple governmental agencies and ministries.

Although the Ministry of Environment and Tourism is active in several international efforts, including trans-boundary park management and tourism, their staff is not well represented in international geospatial fora.

Analytical, Data, Technical, and Infrastructure Issues

The Ministry is trying to document and locate all sources of environmental data to populate the EIMS database. The staff faces communication and coordination challenges among the many relatively new Ministries. The need for improvement in these areas has been acknowledged.

A need for better natural resources inventory data was also identified. In wildlife management, estimates of elephant and other species of wildlife populations vary widely, complicating policy development and scientific approaches to management. Developing updated and more comprehensive national inventories of natural resources is a need that several other agencies with which the team met in Botswana also emphasized. This is an area in which potential collaborations with U.S. Governmental agencies might be explored.

Substantial technical, personnel, and data infrastructure development is needed within the Ministry before its ambitious plans for development of a GIS based EIMS can become a reality. The Ministry recognizes these challenges and wants to overcome them.

Capacity and Ability to Influence Decision-Making

There was sentiment expressed during the meeting of frustration regarding the ability to influence other ministries. However, the Okavango Delta Management plan commissioned by the ministry appears to have influence with the government. The ability to influence governmental decision-making may be greater once the EIMS is up and running. The commitment of ministry personnel to addressing the needs of the nation of Botswana was clear, and through their work, it seems likely that they will begin to at least indirectly influence policy. The Permanent Secretary seemed open and positive about working together with U.S. partners to achieve mutual goals.

Mr. Monna is a young, dynamic and rising expert in the field who may be cultivated to become a champion of the use of geospatial science and technology for sustainable development. His previous experience in developing national conservation strategies and working within the Ministry of Finance and Planning provide him with the contextual knowledge that would be useful in such an instance.

Summary Findings

None provided.

Department of Surveys and Mapping, Ministry of Lands and Housing, Botswana

Mission of the Organization

The mission is to provide superior quality services on land survey, cadastre, mapping, land and geographical information to our customers and stakeholders, with a view to ensuring that land management and development are soundly based to achieve national objectives. The goal is to achieve this mission through strategic modernization of the production system and a well trained, committed, motivated, caring and disciplined work force.

Key Personnel

Goderfrey Biki Habana, Chief Surveyor/Acting Director
Moses Kgwatalala, Geodesist

Geospatial Activities, Research, and Applications

Botswana Survey and Mapping has mapped the entire country at 1:1,000,000 and is currently working on developing 1:50,000 maps for the entire country. The 1:50,000 maps are derived from orthorectified photography captured in 2000. To cover the entire country requires 9,470 sheets. So far that effort is 30 percent complete. Some of the more populated areas are mapped at 1:15,000 with imagery captured in 2003.

As a result of the National Development Plan 8 (NDP8), the department has developed the National Atlas. This is the first ever National Atlas of Botswana, a single bound book comprising 413 pages in 29 chapters containing a wide range of information about the country. The atlas is available over the internet and on CD with the option of obtaining the ArcView version containing 211 maps.

The department has been building a network of over 300 geodetic control points based on the Geodetic Reference System (GRS) 80/WGS 84 datum. With NDP8, the department looks to improve the mapping base with a land use/land cover map and collect a baseline on one to two thousand new settlements in Botswana.

The department is preparing to make a fundamental change in acquiring source data. The goal is to migrate from the historic aerial photography to more current satellite imagery. As a feasibility study, the department ordered one scene of QuickBird imagery.

Capacity and Ability to Influence Decision-making

Although the department is the government's official provider of survey and geographic information, production is hampered by staffing issues. Foreign expertise manages GIS activities. The foreign presence detracts from the department's acceptance and reduces influence on national decision-making processes.

Summary Findings

The department had issues with data sharing within its own government. The lack of coordination also results in overpaying for ESRI software because each agency purchases its own software rather than sharing government-wide site licenses. On the production side, the lack of resources and slow production rate meant that map products quickly became outdated or were already out of date when completed.

As Botswana continues to develop, the demand for the department's services will increase. The department is continuing to move forward on geospatial sciences. The publication of the National Atlas will likely bring more visibility to the department and possibly more support. As the department migrates to satellite imagery, the U.S. could offer support from experienced practitioners in this area. The department could also benefit from a direct source of commercial imagery from NGA or USGS in a bilateral partnership.

Lloyd and Hill, Inc., South Africa

Mission of the Organization

Lloyd and Hill is a private company whose business focuses on land surveying with license to work anywhere in South Africa. They also conduct 3-D laser scanning of buildings and sites.

Key Personnel

Gavin Lloyd, Founder

Geospatial Activities, Research, and Applications

Cadastral mapping is highly developed in South Africa. Land survey data generated by Lloyd and Hill and other land survey companies are entered into a nationwide database administered by the South African Government but housed in each local Surveyor General's office. Gavin Lloyd states that it is possible to search this database and find any parcel in all of South Africa in about two minutes time. It is possible to query, for instance, for all parcels owned by a given company and find them in that timeframe. The results of the search will show the deed and plat map, which they call a "general plan."

In 1997 South Africa passed the Land Survey Act that required all surveys to be tied to the original survey. Subsidiary reference lines are spaced every two degrees of longitude east and west of the original survey line, and these reference meridians continue to be used today for about 2,500,000 land parcels in the country. Each point in the coordinate system is defined by distance from the equator and distance from nearest reference meridian. Each general plan contains two geodetic reference points which serve as a check against tectonic movement of the land itself. The system has been encoded in law to be the Surveyor General's responsibility and to be transparent and open to all.

All parcels were digitized and all new surveys are entered into the same spatial database in the late 1990s. The cadastral base is excellent, but the "quick and dirty" digitization produced a "dodgy" GIS database which is good to about 1 meter accuracy countrywide, with higher accuracy and precision to about 5 cm. in cities. Thus, there is the potential for a "near perfect" cadastre, but the GIS database falls somewhat short of that potential.

Current Collaboration Efforts

Lloyd himself is highly engaged in the geomatics movement in South Africa, and he is currently president of the South African Geomatics Institute. He depends on the universities, both faculty and students, for qualified staff. He believes South African universities must form alliances and laments that the crime problem discourages recruiting.

Analytical, Data, Technical, and Infrastructure Issues

Dr. Lloyd says that South Africa needs to import skills but at the same time is currently exporting them. The country is limited by the lack of skills, though he praises the development of the black middle class that is currently taking place.

Capacity and Ability to Influence Decision-making

Cadastral databases are being used in many aspects of government policy making. Economic development depends on parcel data for land development projects, which is but one of many examples of the importance of this type of information.

Summary Findings

None provided.

Council for Scientific and Industrial Research (CSIR); Department of Science and Technology (DST); and South African Environmental Observation Network (SAEON); Meraka Institute Round Table Discussion, South Africa

Mission of the Organization

CSIR is an approximate analog for the National Science Foundation in the U.S. and provides core funding to S&T agencies of the South Africa government, researchers, universities and NGOs. The Council recently developed a 10-year strategic plan that features as priorities energy, human sciences, health and the environment. Another near-term strategic goal is to establish a National Space Agency to focus on environment and natural resource management, health and safety, security, and economic development and law.

Key Personnel

Dr. Pat Manders, Executive Director CSIR Natural Resources and the Environment;
Mr. Laurie Barwell, R&D Grant Support Manager, CSIR Natural Resources and the Environment;
Dr. Sharon Biermann, Manager, Planning Support Systems, CSIR Built Environment
Pontsho Maruping, General Manager, Frontier Program, DST
Matlou Mabokano, Manager, Resource Based Industries, DST
Avinash Chuntharpursat, Information Management Coordinator, SAEON
Dr. Amani Saidi, Manager, Stakeholder Relations, SAEON
A. Vahid, Meraka Institute

Geospatial Activities, Research and Applications

The CSIR Ecosystem Earth Observation (EcoEO) is a major program with a remote sensing expert group addressing integrated system modeling, oceanographic sensory systems, ecosystem state monitoring, sensor interoperability and time series analysis. Collaborative activities on wildlife and natural habitat conservation using GIS are being conducted with the Kruger National Park. The Carnegie Airborne Observatory, of which CSIR is a partner, is claimed to be cutting edge, particularly for in-situ and remote sensing activities for forest management.

GIS in the CSIR Built Environment program is directed at profiling integrated planning, development and modeling for housing, transport and delivery requirements in both urban and rural developments. Dr. Biermann said that GIS activities had to overcome apartheid suspicions in poorer communities, but the program is robust and now includes an Urban and Regional Dynamics Laboratory. Her unit works closely with the Human Sciences Research Council.

With sponsorship from DST and the National Research Fund, Meraka Institute uses ICTs for earth observation to develop toolsets upstream from imagery; these are directed toward the development of higher education curricula and applied analysis tools for student internships and collaboration. These dynamic platforms of distributed and open source resources are used in the EU Integrated Risk Management System for Africa.

With DST and National Research Fund support, SAEON is operated as a research facility with the core objective of establishing six environmental observatories, or nodes, around the country. The nodes are linked by an information management network used to study environmental change and ecosystems. Node expertise is directed at the climate system, the savanna, grasslands, forests, arid lands and offshore marine habitats.

Current Collaboration Efforts

EcoEO collaboration is sought in the areas of sensor interoperability where some large gaps exist. To address these issues, CSIR and DST are pursuing relations with Central Michigan University, University of Vermont and the University of California, among others. The Built Environment program is collaborating with the Urban and Regional Dynamics Laboratory of the University of Washington (Waddell) and Arizona State University (Guhathakurta, Model for Sustainability). The BE program is also working with Oak Ridge National Laboratory on strategic spatial economic analysis and modeling using LandScan and a mesoframe

approach. Meraka has a current collaboration with the University of Maryland Advance Fire Information System 1, which is proprietary.

Mr. Barwell of CSIR reported on the broad South Africa/U.S. S&T collaboration initiative that began with the Gore/Mubeki Commission in 1995 and continues under an umbrella S&T agreement. The most recent meeting of the Commission in February 2008 in Washington DC, co-chaired by DST and the U.S. Department of State, addressed “grand challenges” for the two countries. These challenges included earth observation and remote sensing needs and common interests; spatial analysis and related training and exchanges between universities and laboratories; source code requirements, including down-scaling to regional and sub-regional bases in climate parameters; joint research projects for three to five years with multiple institutions involved; and “green development” activities with MIT and Harvard. These last two initiatives are evolving under the aegis of a new Africa Center for Earth Sciences and will welcome a large collaborative effort with the EU and Australia, for example. Mr. Barwell also noted that the institutions in Massachusetts are well connected with the South Africa Eastern Cape. A South Africa team is slated to visit the United States to follow up on these grand challenges.

Analytical, Technical, Infrastructure and Data Issues

South Africa has no M.S.- or M.A.-level degrees in GIS disciplines. This was cited as a large deficiency as GIS applications increase in the public and private sectors and insufficient experts are available in the job market. As in other African countries, there are significant generational problems in the South African government and within the university community with respect to understanding and using contemporary GIS sciences and applied analysis as 21st century policy planning tools. Moreover, there are interdisciplinary impediments, for example, in integrating engineers into urban project planning.

Capacity and Ability to Influence Decision-making

The CSIR and DST are critical organizations for strategic planning, program management and funding of geospatial sciences, GIS and related analysis in South Africa. The South Africa/U.S. S&T agreement is a major locus for oversight and planning of collaboration, but the roundtable confirmed that multiple stakeholders exist in both countries and are pursuing collaboration in many geosciences and GIS programs, including with and between universities.

Summary Findings

In the near term, the South African/U.S. collaborative umbrella can foster a new phase of collaboration. At the February 2008 Commission meeting, a working group was established to examine several initiatives, including more university partnerships to establish remote sensing and GIS master's curricula; increased student and faculty exchanges; and establishing more training opportunities such as those facilitated by the American Association of Geographers at international conferences. Fulbright scholarships can also figure in this new level of exchanges.

In the area of spatial analysis, the two sides agreed that more human capital development and technology transfer should be considered in applied programs such as SAFARI 2000. The Meraka Institute representative also proposed to include GIS technology demonstrations in disaster management for floods, cholera and wildfire, for example, as well as the areas of transport, climate change, and oceanography, among others. The U.S. side suggested that NASA/Goddard should be engaged in discussing these areas during the South Africa team follow-up visit in summer 2008. The USGS representative committed to provide current information on the USGS maps of Africa project underway with USAID funding and AAG's Dr. Doug Richardson offered to promote SensorWeb on the AAG website.

South Africa Weather Service (SAWS), South Africa

Mission of the Organization⁷

The South Africa Weather Service aims to be a world class meteorological organization that contributes to the sustainable development of South Africa and beyond. Its mission is to collect, process, and provide meteorological and climatological products and services for the public good and commercial use of all South Africans and beyond.

The South African Weather Service (SAWS)⁸ is an agency under the Ministry of Environmental Affairs and Tourism. The organization provides two distinct services, namely public good services which are funded by government, and commercial services, where the user-pays principle applies.

Key Personnel

Mnikeli Ndabambi

Lawrence Dube, Sr. Manager, Climate Service

Tracey Gill, Asst. Manager Climate Information

Patience Gwaze, Predictive Research.

Geospatial Activities, Research, and Applications

The South African Weather Service is a voice for weather and climate forecasting in South Africa. As a member of the World Meteorological Organization (WMO), it complies with international meteorological standards. As an Aviation Meteorological Authority, SAWS is designated by the state to provide weather services to the aviation industry and to fulfill the international obligations of the government under the Convention of the International Civil Aviation Organization (ICAO). The organization also provides maritime weather forecasting services for the vast oceans around Southern Africa extending to Antarctica. Their clients include industry and government.

The following remote stations contribute to the service observational network:

- 118 Automatic Weather Stations (AWS)
- 112 Climate Stations
- 1 512 Rainfall Stations
- 23 Sea Temperature Stations
- 12 Voluntary Observing Ships
- 50 Weather Buoys in the South Atlantic and South Indian Ocean
- 11 Meteorological Radars
- 1 Global Atmosphere Watch Station at Cape Point
- 2 Dobson Ozone Stations – Irene and Springbok
- 1 Baseline Surface Radiation Network Station – De Aar

SAWS is recovering historical data and archiving it in a sustainable fashion. SAWS has a strong focus on acquisition, management, application and archiving of meteorological and air quality and pollution data. They are involved with working with municipalities nationwide regarding government mandated monitoring for natural hazards. They are also quite involved in developing a geospatial one-stop portal in collaboration with the national disaster management authority.

Current Collaboration Efforts

EUMETSAT designated SAWS as the training institution for the English speaking countries of Africa. The SAWS team is working with the UK Meteorological Office as well as the SADC meteorological services.

SAWS is collaborating with the University of Pretoria to train weather forecasters. A meteorological training center is currently under consideration. SAWS has ongoing research collaborations with the University of the Witwatersrand – Johannesburg, the University of Cape Town, and the historically disadvantaged

⁷ As taken from <http://www.weathersa.co.za/Corporate/MissionVision.jsp>

⁸ As taken from <http://www.weathersa.co.za/Corporate/History.jsp>

university, the University of Zululand. SAWS collaborated with the University of Maryland and the University of Alabama Huntsville.

Within the South African government, SAWS is collaborating with the Agricultural Research Commission, the Department of Water Affairs and Forestry and local municipalities across South Africa.

Analytical, Data, Technical, and Infrastructure Issues

By and large, SAWS has recognized its own limitations and data issues and is now in a phase of addressing these issues. By virtue of the Access to Information Act, SAWS is required to make its data available. They are developing the Geospatial One Stop where the data would be homogenized. They are building in an owner flag for each of the data sets that identifies the original source of the data. This effort is in collaboration with the National Disaster Management Authority.

Regarding the usage and distribution of data from other nations in the region and possible proprietary gains from the development of a value added product, the SAWS delegation interestingly mentioned WMO resolution 14 which prohibits the use of data shared by nations for commercial purposes. All of the members of the SAWS delegation appeared acutely aware of this resolution and the issues related to its enforcement.

SAWS staff solicited help with quality assurance and quality control, especially regarding publications and expertise from the U.S. EPA. EPA has a long term presence in South Africa. SAWS interest areas with EPA involve air quality mapping and forecasting as well as managing climate information and issues of data completeness.

Subsequently there was some discussion of data homogenization by those SAWS members involved with gathering and receiving data from disparate sources. The additional point was made that there has not been as close cooperation amongst all of the municipalities regarding the installation of mandatory emergency preparedness stations as well as air quality monitoring stations. Lack of coordination regarding standardization of sampling and monitoring equipment makes it challenging to gather and homogenize data.

Capacity and Ability to Influence Decision-Making

SAWS has demonstrated for the first time the stacked use of remotely sensed data, meteorological data, and lightning data for a weather catastrophe in southern Africa. They presented this at a WMO meeting. SAWS members were keenly aware of the importance of interfacing with both policy makers and the general public. They are even exploring the possibility of sending weather warnings via SMS and or cell phone messages.

Summary Findings

During concluding discussions, several needs were expressed. One was the need to host a U.S. sponsored fellow, whether an Embassy Science Fellow or Fulbright, who is an expert in geospatial data portals. Another was the need to host a U.S. sponsored fellow in air quality data with expertise in quality assurance and quality control. SAWS would like to host an expert from the U.S. in nowcasting, possibly from the University of Alabama-Huntsville.

There is further need for better linking with the media regarding the dissemination of information. They also want to update existing southern African radar network and enhance the capabilities and the nature of the radar network as well as bring on additional stations to provide complete coverage for South Africa.

There is potential for linking with the meteorological departments in Kenya regarding plans to establish a national radar network of five stations. The two countries should have a dialogue and collaborate on issues regarding radar data and establishing standards.

School of Geosciences and School of Geography, Archaeology, and Environmental Studies, Witwatersrand University, South Africa

Mission of organization

The Schools of Geosciences and School of Geography, Archaeology and Environmental Studies have a mission to teach and conduct research in the earth sciences.

Key Personnel

Professor Charles Mather, Head, School of Geography, Archaeology and Environmental Sciences

Paul Dirks, Head, School of Geosciences

Barend Erasmus, Senior Lecturer, Department of Environmental Sciences

Geospatial Activities, Research, and Applications

The School of Geosciences is one of the largest and most diverse academic earth science institutions in Africa. The School has 191 undergraduate, 42 honors, and 106 postgraduate students, and has a range of analytical facilities. It holds a number of major fossil and mineral collections, with displays in two museums. Education programs are offered in numerous disciplines including geology, paleontology, paleo-anthropology, geophysics, geochemistry, geochronology, environmental science, atmospheric science, economic geology, and exploration and mining geosciences. Wits Geosciences graduates are sought after by mining and minerals industries (internationally), research institutes, government and environmental organizations. The School of Geosciences combines a teaching tradition with a strong research base.

The School of Geography, Archaeology and Environmental Studies has over 100 postgraduate students registered in various postgraduate programs. The school's mission is to build on this foundation of excellence in a way that takes account of the school's responsibilities within South Africa today. The School has an outstanding research record and staff regularly contributes to both local and international journals. It also is involved in policy making and a number of staff members hold positions on high level international research bodies.

The school has an excellent reputation both locally and internationally as one of the leaders in African scholarship on issues such as sustainability, climate change, urban social and environmental justice, tourism and development. The school offers undergraduate programs in the disciplines of Geography and Archaeology and postgraduate degrees in Physical Geography, Human Geography, Environmental Studies, Tourism, Archaeology, Rock Art and Paleo-archaeology. They note that they are one of the most productive research units on campus. School staff contributes regularly to local and international journals and are active members of the editorial boards of many prestigious journals in the fields of geography, archaeology and the broad area of environmental science.

A cross-cutting emphasis of sustainability researchers in the school focuses on issues of environmental justice and vulnerability reduction. Food security and agro-food restructuring are also key research areas, as is research on impacts of globalization on agriculture in southern Africa. The school also specializes in tourism and heritage studies, and on biogeography and biodiversity conservation with species-specific and eco-regional projects throughout the southern African region. Several faculty members also have expertise in urban geography and research on cities and urban governance and sustainability.

Current Collaboration Efforts

A major international program within the School of Geosciences is AfricaArray, an initiative to promote, in the full spirit of the New Partnership for Africa's Development (NEPAD), coupled training and research programs for building and maintaining a scientific workforce for Africa's natural resource sector. The program is funded by public and private partners around the world, including the U.S. NSF, and is run by Penn State University, the Council for Geosciences, and the School of Geosciences. AfricaArray's initial focus is on geophysics to: maintain and develop further geophysical training programs in Africa, in response to industry, government and university needs; promote geophysical research in Africa, and establish an Africa-to-Africa research support system; and obtain geophysical data, through observational networks in participating countries, for studying scientific targets of economic and societal importance, as well as fundamental geological processes shaping the African continent. Data from the AfricaArray program is shared with the Incorporated Research Institutions for Seismology (IRIS), a university research consortium

dedicated to exploring the Earth's interior through the collection and distribution of seismographic data. IRIS programs contribute to scholarly research, education, earthquake hazard mitigation, and the verification of a Comprehensive Test Ban Treaty. Support for IRIS comes from the U.S. National Science Foundation, other federal agencies, and universities.

Meetings with the GDEST team were conducted with Professors Charles Mather, Paul Dirks, and Barend Erasmus of the above Schools at Witwatersrand University. Developing existing and new collaborative relationships with U.S. universities will provide opportunities to help expand core expertise in these areas at Witwatersrand University. Continuing to support the AfricaArray program, while reviewing its effectiveness to date in achieving its training and outreach mission, are other areas for potential collaboration.

Analytical, Data, Technical, and Infrastructure Issues

There is strong interest in expanding the GIS Laboratory and related GIS teaching and research in the School of Geography, Archaeology & Environmental Studies. Hiring and retaining qualified faculty is a current obstacle to expansion of these programs. Competition from private sector and international NGOs for highly qualified GIS professionals has contributed to the challenges of finding “champions” to provide leadership for developing these programs within this and other universities throughout Africa.

Capacity and Ability to Influence Decision-making

The primary focus of geospatial sciences at the University of the Witwatersrand is to train a new cadre of professionals, many of whom may take positions affecting policy and other management decisions. Through such collaborative efforts as the AfricaArray, regional governmental and research institutions may be encouraged to invest in the information infrastructure necessary to monitor environmental and anthropogenic factors affecting sustainable development in Africa.

Summary Findings

The University of the Witwatersrand offers an excellent opportunity to engage well-qualified individuals who have access to excellent facilities in research programs of mutual interest to African regional as well as U.S. partners. This already is taking place in many cases. The AfricaArray effort provides a platform to establish monitoring systems in a spatially representative fashion throughout Africa. Support and/or collaboration by U.S. partners in this field can make a significant contribution to promote the use of geospatial science in various aspects of decision-making as it relates to sustainable development.

Agricultural Research Council – Institute for Soil, Climate, and Water (ARC-ISCW), South Africa

Mission of Organization

Its mission is to promote the sustainable management and use of the agricultural natural resources through research, technology development, technology transfer, and scientific services. Its vision is to be an internationally recognized centre of expertise in the fields of soil science, agro meteorology, remote sensing, geospatial information management, and decision support.

Key Personnel

Dr. Koos Eloff, Acting Research and Technology Manager/Center Manager, Business Management, Executive Management
Terry Newby, Program Manager, Natural Resources Databases, Geo-informatics, Remote Sensing (Satellite and Airborne)
Harold Weepener, Geographical Information Systems;
Dr. Sylvester Mpandeli, Program Manager Agro meteorology
Chris Kaempfer Climate Network Manager;
Analytical Services: No representative present
Adam Look, Division Manager, Soil and Water Analysis;
Nina van Vliet, Plant and Ameliorant Analysis
Dr. Dave Turner, Division Manager, Pedology and Soil Mineralogy
Johan Carstens, Division Manager, Natural Resources and Production Economics;
Dr. Danie Beukes, Program Manager, Soil and Water Science

The Agricultural Research Council has seven areas of key competencies. Each has a program manager, contact person and a number of other personnel responsible for operational activities. ARC has satellite offices in Cedara, Dohne, Glen, Nelspruit, Potchefstroom, Stellenbosch (Infruited), Stellenbosch (Vrendenburg), and Upington.

Geospatial Activities, Research, and Applications

ARC-ISCW conducts applied research and operational projects. According to ARC, the most significant projects are as follows:

AGIS (Agricultural Geo-Referenced Information System);
Umlindi—the Watchman (Drought and Fire Risk Early Warning System);
National assets – Soil, Climate & Satellite Image Databases;
Crop Estimation System for South Africa;
National Land Cover 2000;
WOCAT (World Overview of Conservation Approaches and Technologies);
Land Care Projects in Mpumalanga, Eastern Cape and KwaZulu-Natal; and
Water Harvesting Projects in the Free State, North West Province and Eastern Cape.

A basic asset that supports agricultural research and applications efforts is the network of 500 automated weather stations in addition to the 150 old weather stations that are being converted and modernized. Data from these networks go into a database accessible to researchers. The database is not accessible by the general population or even many management professionals at lower levels of government. Increased accessibility is planned, but dependent upon resource availability.

Another important dataset being produced is from the ARC-Eagle, a four band videography system. Filter selection determines the bands collected and can substitute for hyperspectral data by making multiple collections over the same area using different filter combinations. One application of this technology is assisting in identifying invasive species for the National Invader Vegetation Monitoring program. Another is in the National Crop Estimate System for which the U.S. Department of Agriculture helped develop statistical techniques. The 1:250,000-scale soil association map is also an important resource whose data richness is waiting to be exploited.

The Irrigation Management System is in its infancy. The Agricultural Geo-referenced Information System (AGIS) was officially launched in 2002. It contains dynamic maps, topical information, and administrative information. It is divided into a view side, which contains maps and information for the public, and a

management side, which is used to administer the system and through which additions or modifications to the data and the system can be made. Metadata is an important part of the system. The server is located at and maintained by the South Africa Department of Agriculture.

In addition, there exist other systems either in operation or in development. These include a system containing fire history information, the Weed and Invasive Plants System and others. Remote sensing activities include: satellite data acquisitions for disaster and pest management, agricultural applications, land cover applications, biophysical properties, forestry, clouds, oceans, and miscellaneous activities such as security, intelligence, media, insurance, and 3-D applications. Aerial photography and digital data are acquired for image interpretation to support programs and projects, low level imaging, and digital image processing.

Current Collaboration Efforts

ARC is well connected with other organizations in South Africa: National Department of Agriculture, provincial Departments of Agriculture, Department of Science and Technology, other national departments, international funding agencies, private companies and individuals. ARC-ISCW is also in contact with the U.S. Department of Agriculture.

Analytical, Data, Technical, and Infrastructure Issues

ARC has numerous data and geographic information science and technology programs. Some are nascent and some are well established. Remote sensing data is important to ARC activities and cost is a constant concern. Innovative methods of obtaining important data at a reasonable cost have been developed, such as the airborne videography approach for acquiring important spectral band data when hyperspectral data is not available.

ARC personnel expressed a wish for more frequent satellite image coverage, were concerned over the loss of the full capability of Landsat 7, and would like to see the Landsat follow-on mission take place. Their preference is for it to have the same capability of the earlier versions of Landsat. In the meantime, they are learning to use other satellite data.

Funding is sufficient to meet basic needs and to conduct the many programs at an operational level, but other worthy programs and projects are greatly limited by resource constraints.

Summary Findings

As with other organizations throughout Africa and elsewhere in South Africa, there is a need for people with the proper skill sets. Insufficient remote sensing skills were identified as being of particular importance. Acquisition of sufficient remotely sensed data is a concern as is real time acquisition of hydrological and meteorological data. The difficulties of obtaining data from some agencies are often due to insufficient resources (human and capital) to acquire, process, and distribute the data.

The limited supply of technically trained people in South Africa affects ARC as it does other organizations in the country. Opportunities exist to connect with universities in the United States and elsewhere. The leadership of ARC is interested in GIS and remote sensing training using distance learning. In a subsequent meeting, the GDEST team learned that the CSIR SAR is establishing a training program that might be of interest to ARC.

ARC-ISCW, like other national level organizations in South Africa is modern and presents itself as well managed. It uses advanced technologies on the par with any other modern first world nation. Data issues appear to be manageable as national funding becomes available. It seems fairly well connected with other organizations within South Africa, though some additional connectivity with the CSIR SAR might be of value. ARC is connected with CSIR and acknowledged the important fundamental research role of that organization.

CSIR Satellite Applications Center (SAC), South Africa

Mission of the Organization

CSIR SAC's mission is acquisition and distribution of satellite data to stakeholders.

Key Personnel

Mr. Raoul C. Hodges, Operations Manager and Centre Chief

Dr. Corne Elhoff, Earth Observation Service Centre (EOSC) Manager

Geospatial Activities, Research, and Applications

CSIR facility is not subsidized by the government. The center's business model is based on revenue earned by providing quality services. NASA funded the site until 1976. USGS currently maintains a strong partnership with the site.

The center is divided into two units, Space Operations (SO) and Earth Observations (EO). SO offers turnkey contracts for space launches but EO does not offer that service. SAC believes that providing end-to-end product services would shrink the capabilities market.

SO is an operation that is currently tracking six telecom satellites and is a downlink for six EO satellites. The center has government contracts and international partners. SO is training of a number of individuals from Nigeria. One of the major projects is developing an onsite training center. SAC believes that educating more people will increase the demand for products and services.

The Earth Observation unit also sees the security sector as a future growth market and has already had projects building spatial models for the police department.

Analytical, Data, Technical, and Infrastructure Issues

The center is struggling with the cost of archiving data on digital linear tapes. They also receive no payments for providing students with archived imagery, but a new payment policy is being put into place.

Capacity and Ability to Influence Decision-making

CSIR is the pre-eminent technical research entity within South Africa. CSIR provides analysis and technical solutions to a wide range of geospatial applications used by government and industry.

Summary Findings

CSIR/SAC's primary clients are governmental agencies at the central, provincial and district levels. Their role will need to be resolved with the newly created State Information Technology Agency (SITA) in terms of how SAC will interact with SITA. Their ability to serve municipalities is complicated due to the lack and stability of experience at that level of government.

SAC would like reap benefits from the South African Space Agency, but has concerns that political issues will delay progress in this area. If political issues can be resolved, SAC sees South Africa launching a 2 meter resolution satellite in the next 5 to 10 years. The momentum to launch these satellites is growing as the cost of U.S. and European remote sensing continues to rise. CSIR has set a long-term goal for the Centre to serve as a mission control site for all African owned satellites, which may number at least 15 by the year 2018.

CSIR has a natural role in supporting regional geospatial science and technology applications in the region, particularly in southern Africa. Its ability to do so is constrained by its funding model because governments in the region are reluctant to pay an entity that has been traditionally identified with the South African government. SAC will try to reach out to Namibia and Botswana over the next three years and have already let Botswana know that SAC could act as their ground station so that they don't have to build their own. SAC continues to have a primary focus on South African needs and has not strongly reached out to other regional institutions.

EIS-Africa, South Africa

Mission of the Organization

EIS-Africa is dedicated to providing access to geo-information products and services, as well as building capacity, amongst African countries and institutions to better manage their environment and natural resources. EIS-AFRICA seeks to stimulate effective application of geo-information technologies and techniques to enhance socio-economic development in Africa. This is achieved through disseminating geospatial information products and providing geospatial information services and capacity building.

EIS-Africa is a non-profit, pan-African membership based organization of geo-information practitioners and institutions. The secretariat of EIS-AFRICA is based in Tshwane (Pretoria), South Africa.

Key Personnel

Mr. Sives Govender, Executive Director

Dr. Wilbur Ottichilo, President of the Executive Board

Geospatial Activities, Research, and Applications

EIS-Africa relies primarily on funding from donor grants. Additional minor funding comes from outreach projects, training activities, consulting services and membership fees. Meetings with EIS-Africa Executive Director Sives Govender and former Executive Director Elizabeth indicate that the organization's financial situation is precarious. There are only two full-time staff members (mentioned above), and the annual operating budget needs are approximately \$150,000. To date, the organization has subsisted primarily through funds from international donor agencies, including USAID.

It plays a leading role in supporting the development of an African society where high quality geospatial, environmental and earth observation data and information are readily available and accessible to policy and decision-makers. It believes that the use of integrated environmental and spatial information management systems and their related applications contribute toward the development of sustainable development policies and practices thereby improving the well being of people in African countries.

EIS-Africa is recognized by key strategic partners, clients and the public as a leading organization developing African capacity to generate, manage, disseminate and use geospatial and environmental information to enrich policy debate and support decision-making. It has provided a framework for assisting African countries in assessing and meeting expressed needs for the management of information on the environment, natural resources, and sustainable development. EIS-Africa also maintains a comprehensive contact database with close to 6000 contacts. This database is updated on an almost daily basis and is accessible via their website.

Current Collaboration Efforts

Collaborative activities might include working with EIS-Africa to establish a more sustainable, long-term funding model, which might mix increased membership fees, meeting registration fees, small research and outreach programs, publications revenue, GIS Professional Certification program fees, and other sources of funds. Increasing membership fees would require the development of a suite of valued services and publications that would attract members to the organization, such as policy monitoring on behalf of its members, publications, and a certification program. Services and organizational models developed by U.S. professional associations such as the Association of American Geographers (AAG) and the Geographic Information Systems Certification Institute (GISCI, of which the AAG is a founding organization) may be useful, if adapted to local needs and circumstances.

Capacity and Ability to Influence Decision-making

EIS-Africa benefits from its access to 3,000 regional experts in geospatial science and technology. This is emphasized by its role as the primary organizer of the well-established Africa GIS conference, held biannually on a rotational basis in countries throughout Africa.

UNECA's Committee on Development Information, Science and Technology (CODIST) engaged EIS-Africa to establish spatial data infrastructure policies. It is supporting UNEP in the use of geospatial information, and FAO in land use/land cover mapping.

Summary Findings

EIS-Africa is one of the cornerstones of the broader network of professionals applying and promoting geospatial science and technology in the region. Its funding and management structure, however, remains precarious and support is essential. A broader international funding base is needed for EIS-Africa to achieve a sustainable footing, stronger membership allegiance and improved member support mechanisms.

Directorate of Surveys and Mapping, South Africa

Mission of the Organization

The Chief Directorate of Surveys and Mapping strives for excellence through ensuring the availability of reliable and up-to-date national survey, mapping and other geospatial information and services to the public and private sectors, national and international communities, and South Africa. The directorate aspires to be South Africa's foremost organization supplying geospatial information.

Key Personnel

Derek Clark, Chief Director of Surveys and Mapping
Richard Wannacott, Director of Survey Services

Geospatial Activities, Research, and Applications

The Directorate of Surveys and Mapping traces its lineage over 250 years to the efforts of Abbe de LaCaille and Sir George Everest to establish a meridian arc northwards from Cape Town. This process resulted in the establishment of a Directorate of Trigonometrical Survey in 1919, which became the Directorate of Surveys and Mapping. The South African government promulgated the Land Survey Act of 1997, which established TrigNet, a series of 37 GPS base stations to provide geo-referencing services to the public.

Surveys and Mapping provides various products. They are the official generators and repository for topographic maps and related aerial photography. All of their products are available free or sold through certified re-sellers. Highly technical products for use in surveys are sold on a cost recovery basis.

Surveys and Mapping has launched the MapAware Project to promote map awareness and literacy at the primary school level and adult learners. They provide schools with curriculum, learning materials, and wall maps to that are tailored to cover the local geography. They also carry out workshops for adults that demonstrate the ability to use aerial photographs and maps; application of geographical coordinate systems, and to apply spatial information to effective decision-making related to land, sustainable development and natural resources.

Current Collaboration Efforts

TrigNet was established in collaboration with the National Land Survey of Sweden, the South African Weather Bureau, Eskom, Telkom, the Hermanus Magnetic Observatory, the Council for Geoscience, the Hartebeesthoek Radio Astronomy Observatory, and various local authorities.

Lands and Surveys also has collaborated with the National Spatial Information Framework to develop infrastructure to use spatial information in decision-making. This entity, within the Department of Land Affairs, is a member of the Global Data Infrastructure organization.

Lands and Surveys has provided financial resources to the Mapping Africa for Africa (MAFA) effort. This UNECA/CODIST led effort is endorsed by the NEPAD Secretariat. MAFA's initial phase involves cataloguing and identifying gaps in national baseline data throughout Africa. This phase was contracted to EIS-Africa and the Africa Geo-Information Research Network.

The Africa Reference Framework (AFREF) project supports a UNECA to unify the coordinate reference frames in Africa. AFREF uses global navigation satellite systems to create a uniform and consistent coordinate frame based upon the International Terrestrial Reference System and Frame. AFREF seeks to establish a network of GPS base stations throughout Africa and to develop the human capacity to use this network. Thus far, conferences have taken place covering northern African countries and southern African countries. The U.S. State Department Bureau of Oceans Environment and Space and the UN Office of Outer Space Affairs have supported the effort.

Analytical, Data, Technical, and Infrastructure Issues

Lands and Surveys is primarily concerned with establishing key survey points, particularly a network of GPS base stations for accurate surveys. This is particularly important to South Africa as it begins the complex process of addressing land tenure and land distribution efforts. Lands and Surveys is also concerned about increasing citizen awareness and capacity to effectively use maps.

Lands and Surveys has suffered a high turnover rate in its staff. Ironically, many of the pre-eminent commercial providers of survey and mapping services started out within the Directorate. Much of the senior expertise is actively being replaced, but the Directorate is threatened about loss of its best institutional knowledge.

Capacity and Ability to Influence Decision-making

Land and Surveys has a high level of capacity. As the official source of surveys and mapping to the government, it has a direct impact on all geospatial elements of national and local policy formulation. They are also well-regarded internationally, particularly within Africa, which places the Directorate in an excellent position to affect regional deliberations on applications of geospatial sciences and technology.

Summary Findings

Lands and Surveys is a key player in the establishment of GPS reference systems in Africa. Their level of expertise and reputation may be harnessed in promoting the effective use of geospatial tools throughout the region.

Lands and Surveys has not openly embraced regional non-governmental efforts to generate networks of regional experts. This apparent paradox between expertise, interests and actions, should be addressed.

Appendix 3: GDEST Team

Team West Delegation



Melba Crawford is Assistant Dean for Interdisciplinary Research in the Colleges of Agriculture and Engineering at Purdue University and has academic appointments in Agronomy and Civil Engineering. She heads the Laboratory for Applications of Remote Sensing and holds the Purdue Chair of Excellence in Earth Observation. Dr. Crawford received the B.S. and M.S. degrees in Civil Engineering from the University of Illinois, and the Ph.D. degree in Systems Engineering from the Ohio State University. She was Professor of Mechanical Engineering at the University of Texas, Austin, until 2006 when she joined Purdue University. She has more than 100 publications and is internationally recognized as an expert in analysis of remote sensing data. In 2004-2005, Dr. Crawford was as a Jefferson Senior Science Fellow at the U.S. Department of State. She is a Fellow of the IEEE and an Associate Editor of the IEEE Transactions on Geoscience and Remote Sensing. Dr. Crawford served as a member of the NASA Earth System Science and Applications Advisory Committee and was a member of the NASA EO-1 Science team, which received a NASA Outstanding Service Award. She currently serves on the advisory committee to the NASA Socioeconomic Applications and Data Center.



Jerome (Jerry) E. Dobson is a Professor of Geography at the University of Kansas and President of the American Geographical Society. He was recently elected as a Fellow of the American Association for the Advancement of Science. He is a Fellow of the Royal Geographical Society and currently serves as Chair of the Honors Committee of the Association of American Geographers. He holds a Ph.D. in geography from the University of Tennessee (1975), M.S. and B.A. in geography from the University of Georgia (1972, 1967), and A.A. from Reinhardt College (1965). Dobson's principal contributions include the paradigm of automated geography, his instrumental role in originating the National Center for Geographic Information and Analysis (NCGIA), his leadership of the effort to advance remote sensing methods for large-area change analysis as part of NOAA's Coastal Change Analysis Program (C-CAP), and his leadership of the LandScan Global Population Database, which has become the de facto world standard for estimating populations at risk during natural disasters, wars, and terrorist acts (including biological and chemical agents).



Fernando R. Echavarría is a Foreign Affairs Officer in the U.S. Department of State's Office of Space & Advanced Technology in the Bureau of Oceans, Environment and Science (OES/SAT). His portfolio at the State Department is focused on various applications of geospatial and renewable energy technologies to address sustainable development. He was the State Department lead for the Geographic Information for Sustainable Development (GISD) initiative, a U.S. deliverable to the World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa held in 2002. He currently co-chairs with the U.S. Department of Energy an interagency working group promoting the development of geothermal energy resources in the African Rift Valley and South America. Dr. Echavarría's research and publications have focused on the use of remote sensing and Geographic Information Systems (GIS) to monitor environmental change. His publications have appeared in the following journals: *AMBIO- A Journal of the Human Environment*, *Geocarto International*, *International Journal of Remote Sensing*, Pan American Institute of Geography and History's (IPGH) *Revista Geografica*. His last book chapter appeared in 2000, in K. Zimmerer and K. Young (eds.) *Nature's Geography*.



Lawrence Lin is currently a fellow of the American Association for the Advancement of Science (AAAS) at the Office of the Science and Technology Adviser to the Secretary of State. Prior to his current work, he did a fellowship at the National Academy of Sciences and worked on the initial phases of a comprehensive energy technology study titled America's Energy Future. Dr. Lin completed his Ph.D. in physics at the University of California, Santa Barbara in 2006. His graduate research involved the use of simplified elastic models of biological membranes to do theoretical calculations and perform simulations as a means for studying the role of membrane undulations in various biophysical processes. His undergraduate studies were done at Brown University where he wrote a thesis in the area of cosmology and large scale structure of the universe.



Timothy Mroz is a Geospatial Analyst at the National Geospatial-Intelligence Agency (NGA) in the St. Louis facility. He joined NGA in 1986 as a cartographer assigned to the digital collection branch and his duties included the collection and finishing of this data to produce many different geospatial products. In 1999 Timothy joined the Eurasia-Africa division. Currently, his region of focus is Western Africa. In his position, he produces local and regional map products to support situational awareness and policy making, working with remote sensing and GIS software. Timothy earned a BS in Geography-Cartography from University of Wisconsin-Whitewater in 1984. During his twenty year career in the fields of remote sensing and GIS he has specialized in satellite imagery, along with the collection of digital data. Timothy recently supported NGA at Africa Days at Bethesda, MD.



Lee Schwartz is The Geographer of the Department of State and the Director of its Office of The Geographer and Global Issues in the Bureau of Intelligence and Research. Previously, he held positions as division chief for Global Issues and for United Nations and Humanitarian Concerns. Schwartz is the Department's 9th Geographer, a position established in 1921 and, according to federal regulations, is responsible for providing guidance to all federal agencies on questions of international boundaries and sovereignty claims. His B.A. was from Bucknell University and his M.A. and Ph. D. were from Columbia University, with specialties in political and population geography. Prior to joining the Office of The Geographer in 1992, Dr. Schwartz was a member of the faculty of The American University's School of International Service. At the Department of State, he has directed research and analysis on global issues primarily related to complex humanitarian emergencies and has coordinated related fieldwork and applied geography projects overseas, including in the Balkans, Central Asia, Russia, Afghanistan, Iraq, Sudan, and the Horn of Africa. His recent work has focused on ethnic conflict, refugee flows, peacekeeping operations, strategic warning, conflict mitigation and response, and GIS information coordination. He was the State Department's 2005 winner of the Warren Christopher Award for Outstanding Achievement in Global Affairs.



Gray Tappan holds a M.A in Geography and B.A.s in Geography and French from the University of Kansas. He has 27 years of experience working as a geographer on international development programs in Africa and Central America. His professional interests include natural resource mapping and monitoring, studying land cover changes over time, and applying remote sensing to a variety of environmental problems. Gray is currently a Principal Scientist at the USGS Center for EROS in Sioux Falls, South Dakota, where he has worked since 1987. He is presently leading several projects in West Africa that use remote sensing to characterize natural resource changes and land management practices. His special interest is in long-term environmental monitoring, on the ground and through imagery. He has worked in West Africa over the past 25 years mapping and tracking trends in land cover, biodiversity, and has documented both degradation and successes in local practices that have improved peoples' livelihoods and their environment.

Team East Delegation



Paul Bartel is Senior Advisor to the Humanitarian Information Unit at the U.S. Department of State. His background as an economist and geographer ranges from natural resource management and food security to strategic planning. He has previously served as Environmental Information Advisor to the USAID Africa and EGAT Bureaus and has acted as a consultant to FAO and the International Water Management Institute on geospatial issues. Mr. Bartel has lived and worked extensively in Africa and Latin America, on natural resource management and famine early warning issues. He has recently conducted analyses on the impacts of hostilities on the Lebanese agricultural sector, the implications of China's foreign assistance paradigm on humanitarian issues in Zimbabwe, and the impact of US Government humanitarian programs on coca production and conflict in Colombia. Currently, he is coordinating a high level series of site visits and a conference on geospatial sciences for sustainable development in Africa.



Jason Bourisaw is a Geospatial Analyst at the National Geospatial-Intelligence Agency (NGA) in the St. Louis facility. Jason joined NGA in 2005 at which time he was assigned to the Eurasia-Africa division. Currently, his region of focus is Central and Southern Africa. In his position, he produces local and regional map products to support situational awareness and policy making. Jason earned a M.S. in Environmental Engineering from Southern Illinois University Edwardsville in 2005; and a B.S. in Geological Engineering from the University of Missouri-Rolla in 1996. During his twelve year career in the fields of remote sensing and GIS, he has specialized in satellite imagery. Before joining NGA, he was part of the government production team for Orbimage now GeoEye which operates two high resolution commercial satellites.



Joshua Comenetz is Chief of the Geographic Studies Branch in the Population Division of the U.S. Census Bureau. At the Census Bureau, he supervises subnational demographic estimates and mapping, including geo-demographic components of the Pop@Risk (populations at risk from natural disasters and humanitarian crises) effort. Dr. Comenetz authored the 11th edition of the Atlas of World Affairs (Routledge) and has published numerous research articles on international and domestic population change, cartographic visualization, and related topics involving geographic information systems and spatial data. He is one of the editors of Goode's World Atlas (Rand McNally). As a consultant he has solved problems in areas ranging from political redistricting to ethnic mapping. Prior to joining the Census Bureau, he taught geography, international relations, and data quality analysis at the University of Florida. He holds an A.B. in geology from Harvard and an M.A. and Ph.D. in geography from the University of Minnesota.



Dr. John Kelmelis is Senior Science Advisor for International Policy at the U.S. Geological Survey and Senior Counselor for Earth Science at the U.S. Department of State. He is leading an effort to identify emerging earth science findings with foreign policy implications. He has served as Chief Scientist for Geography at USGS and led the scientific activities of the Cooperative Topographic Mapping, Land Remote Sensing, and Geographic Analysis and Monitoring Programs. He was the first coordinator of the USGS Global Change Research Program, managed the United States Antarctic Mapping Program, and was Director of the White House Scientific Assessment and Strategy Team. He was a Visiting Scientist at the Smithsonian Institution and a staff member of the Subcommittee for Space Sciences and Applications at the U.S. House of Representatives. He received his Ph.D. in geography from the Pennsylvania State University, and holds an M.S. in engineering management and B.A. in earth science. He has more than 100 papers and other publications to his credit. John is a counselor of the American Geographical Society, is active in the Association of American Geographers, American Geophysical Union, American Society for Photogrammetry and Remote Sensing, and other professional organizations.



Kate Lance, in conjunction with NASA, USAID, CATHALAC (in Panama), and the Regional Centre for Mapping of Resources for Development (RCMRD) (in Kenya), is crafting a work plan and partnerships for SERVIR activities in Africa. SERVIR is a regional visualization and monitoring system using satellite imagery and GIS, already operational in Meso-America and contributing to climate change analysis, environmental management, and disaster response. Kate holds a master's degree in forestry from Yale University and soon should complete a Ph.D. at the International Institute for Geo-information Science and Earth Observation (ITC) and Wageningen University, Centre for Geo-Information in The Netherlands. The focus of her Ph.D. research is on cross-agency coordination of government geospatial information systems. The research builds upon Kate's practical experience in over 20 countries, in which she collaborated with GIS specialists from national statistics institutes, national mapping agencies, and ministries of environment and agriculture in addressing socio-technical issues related to spatial data infrastructure (SDI) development. She continues to Co-Chair the Global Spatial Data Infrastructure Association (GSDI) Legal and Economic Committee and is Editor of the widely read SDI-Africa newsletter.



Andrew W. Reynolds is a career civil servant of 35 years. Since August 2000, he has served as Deputy and chief of staff for the Office of the Science and Technology Adviser to the Secretary of State (STAS), U.S. Department of State. STAS leads efforts to increase S&T and engineering personnel and literacy at the Department; strengthen outreach to the domestic and international S&T community; and foster mid- to long-term strategic planning to address S&T and engineering issues in foreign policy at U.S. State Department, USAID, and the U.S. Government, including the defense and intelligence communities. Mr. Reynolds worked for 15 years at the U.S. Department of Energy (DOE), where he specialized in energy supply and demand forecasting and analysis, nuclear power and export controls. He served in Paris as DOE Representative for Europe in the U.S. Mission to the Organization for Economic Cooperation and Development and the Nuclear Energy Agency. In 1990 he joined the Office of S&T Cooperation at the State Department. From 1996, he served as Counselor for Environment, Science and Technology at the U.S. Embassy in Rome under a Limited Foreign Service appointment. Mr. Reynolds holds a B.A. in international relations and pre-medical studies from the University of Virginia, M.S. in energy technology management from the George Washington University and M.S. in strategic intelligence from the National Military Intelligence College.



Douglas Richardson is the Executive Director of the Association of American Geographers. Prior to joining the AAG, Dr. Richardson had founded and was the president of GeoResearch, Inc., which created and patented the first real-time interactive GPS/GIS technologies, and pioneered the development of related GPS/GIS field mapping and geographic management applications internationally for over a decade. He sold the company and its key patents in 1998. He has conducted extensive research in the environmental and natural resources fields, and on geographic and mapping technologies. He also has worked closely with American Indian Tribes on sustainable development issues for many years. His current research interests focus on geography's evolution as an international discipline and its future trajectories in the university and in society.



Robert (Bob) J. Swap is an Associate Professor in the Department of Environmental Sciences at the University of Virginia. He has over 20 years of international environmental research experience. Thematically, this research has been directed at observations of interactions between the land and atmosphere systems. Geographically, a majority of the research has been directed at understanding these phenomena central southern Africa. He has conducted research in Botswana, Mozambique, Namibia, South Africa and Zambia. Prof. Swap has participated, helped developed and led the Southern African Regional Science Initiative (SAFARI 2000). The initiative involved hundreds of scientists and students from over a dozen countries and focused on aerosol and trace gas emissions, transports and impacts. SAFARI resulted in dozens of advanced degrees for African students. More recently, Prof. Swap helped develop an international collaboration known as the Southern African Virginia Networks and Associations (SAVANA) consortium of institutions of higher learning in Botswana, Mozambique, South Africa and the U.S.

Appendix 4: GDEST Contacts

Team West Contacts

Senegal			
Souléye Wade	Faculty	Université Cheikh Anta Diop, Applied Remote Sensing Laboratory	wadesouleye@yahoo.fr
Cheikh Mbow	Faculty	Université Cheikh Anta Diop	cmbow@ucad.sn
Amadou Diaw	Directeur	Laboratoire d'Enseignement et de Recherche en Géomatique	atdiaw@ucad.sn
Assize Toure	Directeur Technique	Centre de Suivi Écologique (CSE)	assize@cse.sn
Amadou Moctar Niang	Directeur Général	CSE	niang@cse.sn
Youssou Ndong	Directeur	Direction des Travaux Géographiques et Cartographiques	dirdtgc@sentoo.sn
Mouhamed Tidiane Seck	Directeur Général	Agence De l'Informatique de l'État (ADIE)	tidiane.seck@adie.sn
Sada Wane	Directeur Général Adjoint	ADIE	sada.wane@adie.sn
Cheikhou Ly	Directeur des Relations Exterieures et de la Communication	ADIE	cheikhou.ly@adie.sn
Aliou Dia	Senegal Roundtable	UNOCHA	alioudia200@yahoo.fr
Ibrahima Dia	Senegal Roundtable	Mission de Formulation de MCA Sénégal	ibradia@refer.sn
Abdul Aziz Gueye	Senegal Roundtable	Cabinet GMZ	aziz.gueye@orange.sn
Moustapha Mbacké Ndour	Senegal Roundtable	ASIGEO	ndour_moustapha@yahoo.fr
Mamadou Niane	Senegal Roundtable	Wetlands International	mamadou@nianefamily.com
Mouhammadou Diop	Senegal Roundtable	ASIGEO	mouhammade@yahoo.com
Ndiaye Mandiaye	Senegal Roundtable	President ASIGEO	mnjaye@yahoo.fr or asigeao1@yahoo.fr
Amadou Hadji	Senegal Roundtable	ISMRR	ismrr@hotmail.com
Racine Kane	Senegal Roundtable	IUCN	racine.kane@iucn.org
Mamadou Thiam	Senegal Roundtable	DTGC	thiammor@hotmail.com
Gora Beye	Senegal Roundtable	CSE	gora.beye@cse.sn
Ousmane Fall Sarr	Senegal Roundtable	ASER	ofsarr@aser.sn
Burkina Faso			
Abdoulaye Belem	Directeur Technique	Institut Géographique du Burkina Faso	abdoulaye.belem@igb.bf

Patrice Sanou	Directeur Général	Centre de Système d'Information Géographique et Télédétection –Adjaratou	sanou@fasonet.bf
Laurent Sedogo	Minister	Ministère de l'Environnement et du Cadre de Vie	sedogo.mecv@mee.gov.bf
Bamory Ouattara	Directeur Général	Institut National de la Statistique et de la Démographie	bamoryouatt@yahoo.fr
Tanga Pierre Zoungrana	Faculty	Department de Géographie, Université de Ouagadougou	tpzoung@yahoo.fr
François de Charles Ouedraogo	Faculty	Department de Géographie, Université de Ouagadougou	francois.ouedraogo@ird.bf
Lassane Yameogo	Faculty	Department de Géographie, Université de Ouagadougou	yameogolass@gmail.com
Honoré Somé	Faculty	Department de Géographie, Université de Ouagadougou	someph@fasonet.bf
Paul Ginies	General Manager	L'Institut international d'Ingénierie de l'Eau et de l'Environnement (2iE)	paul.ginies@2ie.org
Philippe Girard	Scientific Advisor	2iE	philippe.girard@2ei-edu.org
Corentin Som	Head, GIS Unit	2iE	corentin.some@2ei-edu.org
Salif Sow	Regional Representative	FEWS NET West Africa	ssow@fews.net
Niger			
Mohamed Yahya Ould Mohamed Mahmoud	Directeur Général	AGRHYMET	m.yahya@agrhyment.ne
Seydou Traore	Chef Unité Coordination Scientifique	AGRHYMET	s.traore@agrhyment.ne
Brahima Kone	Chef Département Appui Technique	AGRHYMET	b.kone@agrhyment.ne
Faustin Gnoumou	Chief of Dept. of Education and Research	AGRHYMET	f.gnoumou@agrhyment.ne
Brahima Sidibe	Chief Dept. of Information and Research	AGRHYMET	b.sidibe@agrhyment.ne
M.Henri Songoti	Chief of the Database Division	AGRHYMET	songoti@agrhyment.ne
Mahamane Larwanou	Faculty	Universite Abdou Moumouni	m.larwanou@coraf.org
Guero Yadjji	Faculty	Université Abdou Moumouni	fragrony@refer.ne
Hassimi Adamou	Director General	Institut Géographique National	ah_dabey@yahoo.fr
Nigeria			
Ismail Iro	General Manager	Abuja GIS	ismail@gamji.com
Roland Klaus	Project Manager	Abuja GIS	roland_klaus@julius-berger.com
Yahaye Tahirou	National Representative	FEWS NET Nigeria	y.tahirou@fews.net

Victor Ajieroh	Southern Coordinator	FEWS NET Nigeria	vajieroh@fews.net
Wayne Frank	Agriculture Development Officer	FEWS NET Nigeria	wfrank@usaid.gov
Latanya Mapp Frett	Director, Partnership Office	USAID	lmapp@usaid.gov
Muhammed Audu	Vice-Chancellor	Federal University of Technology (FUT), Minna	audumso@yahoo.com
P. S. Akinyeye	Head, Department of Geography	FUT Minna	
M. T. Usman	Director, Collaboration, Affiliation, and Linkages	FUT Minna	cal@futminna.org
Suleiman Sadiku	Faculty	FUT Minna	drsadiku@yahoo.com
Appollonia Okhimamhe	Faculty	FUT Minna	aimiosino@yahoo.com
M. M. Audu-Bida	Director General	National Emergency Management Agency (NEMA)	audubida470@yahoo.com
Kayode Fagbemi	Head, Mission Control Center	NEMA	kayodef@hotmail.com
Halilu Ahmad Shaba	Head, GIS Unit	NEMA	drhalilu@yahoo.com
Juliet Ezechie	CEO	GeoQinetiq	juliet.ezechie@geoqinetiq.com
H. O. Davies	Assistant Director	Nigeria Geological Survey Agency	rkbases_res@yahoo.com
O. A. C. Ugwuja	Director, Applied and Engineering Geology Department	Nigeria Geological Survey Agency	ugwujaclement@yahoo.co.uk
Dr. Robert A. Boroffice	Director-General/Chief Executive	National Space Research and Development Agency (NASRDA)	
Joseph Akinyede	Director, Space Applications	NASRDA	jakinyede@nasrda.gov.ng
Ganiy Agbaje	Head, Mission Control & Data Management	NASRDA	gagbaje@nasrda.net
Olufemi Agboola	Deputy Director, Engineering and Space Systems	NASRDA	agbula3@yahoo.com

Team East Contacts

Uganda			
Johnson Owaro	Coordinator for Disaster Preparedness	Office of the Prime Minister, Office of Disaster Preparedness and Management	
Frank Kansiime		Makerere University Institute of Environment & Natural Resources	fkansiime@muenr.mak.ac.ug
Panta M. B. Kasoma	Chief of Party	Productive Resource Investments for Managing the Environment Western Region	panta_kasoma@dai.com panta_kasoma@yahoo.com
Shuaib Lwasa		Urban Harvest	s.lwasa@cgiar.org
Eugene Muramira	Director, Policy Planning and Information	National Environment Management Authority (NEMA)	
Mary Goretti Kitutu Kimono	Environment Information Systems Specialist	NEMA	gkitutu@nemaug.org
James William Mubiru		Uganda Bureau of Statistics (UBOS)	james.mubiru@ubos.org
Andrew Mukulu	Director, Population and Social Statistics	UBOS	andrew.mukulu@ubos.org
Bernard Muhwezi	Principal Geo-Information Officer	UBOS	bernard.muhwezi@ubos.org
Charles Adriku	Senior Geo-Information Officer	UBOS	charles.adriku@ubos.org
Godfrey Nabongo	Communications Manager	UBOS	godfrey.nabongo@ubos.org
Dan Temu		Nile River Basin Initiative	dtemu@nilebasin.org
Hellen Natu		Nile River Basin Initiative	hnatu@nilebasin.org
Rwanda			
Silas Lwakabamba	Rector	National University of Rwanda (NUR)	rector@nur.ac.rw
Kurt Brassel	Director	Centre for Geographic Information Systems (CGIS-NUR)	kbrassel@cgisnur.org
Michele Adesir-Schilling	Senior Lecturer	CGIS-NUR	
Jean Pierre Hitimana	Head of Geo-IT Unit	CGIS-NUR	
Deo R. Rutamu	Project Coordinator for Rwanda Development Gateway (RDGG)	CGIS-NUR	
Nicole Ueberschaer		CGIS-NUR and Technische Fachhochschule Berlin	
Stefan Kappeler		CGIS-NUR, Kigali Office	stefan.kappeler@cgisnur.org
Michael Sittard		ESRI-Germany (in Rwanda)	M.Sittard@ESRI-Germany.de

Mike Hughes	Science, Technology, Research Adviser	Ministry of the Presidency of the Republic (MINIPRESIREP)	m.hughes@yahoo.com
Patricia Hajabakiga	Minister of Lands and Environment	Ministry of Lands (MINITERE)	phajabakiga@yahoo.co.uk
Kenya			
Peter Ndunda	GIS Specialist	Greenbelt Movement	pndunda@greenbeltmovement.org
David Kinyua	Regional Environmental Advisor	USAID	dkinyua@usaid.gov
Laban A. Ogallo	Director	IGAD (Intergovernmental Authority on Development) Climate Prediction and Application Centre	logallo@icpac.net
Wilber Ottichilo		Regional Centre for Mapping of Resources for Development (RCMRD)	wottichilo@rcmr.org
Tesfaye Korme	Director Remote Sensing, GIS, and Mapping Development	RCMRD	tkorme@yahoo.co.uk , korme@remrd.org
Jess Grunblatt		United Nations Environment Programme (UNEP)	jess.grunblatt@unep.org
Peter Gilruth		UNEP	
Mick Wilson		UNEP	mick.wilson@unep.org
Botswana			
Lars Ramberg	Director	University of Botswana, Harry Oppenheimer Okavango Research Center (HOORC)	lrarnberg@orc.ub.bw
Susan Ringrose		HOORC	sringrose@orc.ub.bw sueringrose@hotmail.com
M.M.S. Kgatalala		Government of Botswana, Department of Surveys and Mapping	mkgatalala@gov.bw
L.M. Phalaagae		Government of Botswana, Department of Surveys and Mapping	LPhalaagae@gov.bw
G.B. Habana		Government of Botswana, Department of Surveys and Mapping	ghabana@gov.bw
K. Naran		Government of Botswana, Department of Information Technology	knaran@gov.bw
Edson Selaolo	Director	Government of Botswana, Department of Research, Science, and Technology	eselaolo@gov.bw
Lesego Motlatsi Motoma,	Deputy Director	Government of Botswana, Department of Research, Science, and Technology	lmotoma@gov.bw
J.I. Molefe		University of Botswana, Department of Environmental Science	molefeji@mopipi.ub.bw
R.J. Sebego		University of Botswana, Department of Environmental Science	Sebegorj@mopipi.ub.bw

S. Mugisha		University of Botswana, Department of Environmental Science	mugisha@mopipi.ub.bw
O. Areola		University of Botswana, Department of Environmental Science	areolao@mopipi.ub.bw
R. Chanda	Department Head	University of Botswana, Department of Environmental Science	chandar@mopipi.ub.bw
O.P. Dube		University of Botswana	dubeop@mopipi.ub.bw dubemop@yahoo.com
Musisi Nkambive		University of Botswana	musisin@mopipi.ub.bw
T.J. Agiobenebo		Botswana Institute for Development Policy Analysis	agiobenebot@bidpa.bw
Joel Sentsho		Botswana Institute for Development Policy Analysis	jsentsho@bidpa.bw
Tebogo Seleka		Botswana Institute for Development Policy Analysis	tseleka@bidpa.bw
N.H. Fidzani	Executive Director	Botswana Institute for Development Policy Analysis	
Boga Fidzani		National AIDS Coordinating Authority	
Wayne Gill		National AIDS Coordinating Authority, Monitoring and Evaluation section, from UNAIDS	
Kent Berger	GIS consultant	National AIDS Coordinating Authority	
Tiyapo Hudson Ngwisanyi	Principal Geophysicist, Acting Director	Government of Botswana, Geological Survey	tngwisanyi@gov.bw
Ngonidzashe Isaac Tobani	Environmental Engineering/Hydroge ologist	Government of Botswana, Geological Survey	ntobani@gov.bw
Gomotsang Tshoso	Principal Geophysicist	Government of Botswana, Geological Survey	gtshoso@gov.bw
Dikabo Mogopadi		Government of Botswana, Geological Survey, Chemistry Laboratory	dikmog@yahoo.co.uk
Mosaboswa Hilary Koketso	Principal Geophysicist	Government of Botswana, Geological Survey	mkoketso@gov.bw
Lekgoa Lesole	Senior GIS Officer	Government of Botswana, Geological Survey	llesole@gov.bw
Regina Mokgosi		Government of Botswana, Geological Survey, Cartography Section	rmokgesi@gov.bw
Milton Keeletsang		Government of Botswana, Geological Survey, Borehole Data Management	mkeeletsang@gov.bw
Shadrack Mogapi		Government of Botswana, Geological Survey, Cartography Section	smogapi@gov.bw
Magowe Magowe	Principal Hydrogeologist	Government of Botswana, Geological Survey	magowe@yahoo.com

Paolo D'Odorico	Associate Professor	University of Virginia, Department of Environmental Sciences	paolo@virginia.edu
Thoralf Meyer	Director	Services for Geo-information	gmo_maun@yahoo.com
Gregory S. Okin	Assistant Professor	UCLA Department of Geography	okin@geog.ucla.edu
O.G.S.O Kgosidintsi	Science Technologist	University of Botswana	kgosidintsi@gmail.com
South Africa			
Pontsho Maruping	General Manager	Department of Science and Technology	pontsho.maruping@dst.gov.za
Amani Saidi	Manager, Stakeholder Relations	South African Environmental Observation Network (SAEON)	amani@saeon.ac.za
Tracey Gill	Assistant Manager, Climate Information	South African Weather Service	tracey.gill@weathersa.co.za
Mnikeli Ndabambi		South African Weather Service	mnikeli.ndabambi@weather.sa.co.za
Barend Erasmus	Lecturer, School of Animal, Plant, and Environmental Science	University of the Witwatersrand	barend@gecko.biol.wits.ac.za
Frank Eckardt	Senior Lecturer, Department of Environmental and Geographical Science	University of Cape Town	eckardt@science.uct.ac.za
Michael Inggs	Faculty	University of Cape Town, Department of Electrical Engineering	michael.inggs@uct.ac.za
Guy Midgley	Chief Specialist Scientist, Global Change Research Group	National Biodiversity Institute	midgley@sanbi.org
Gavin Lloyd	Founder	Lloyd & Hill, Inc.	gavin@lloydhill.co.za
Sives Govender	Executive Director	EIS-Africa	sgovender@eis-africa.org
Thomas L. Lewis	Director of Marketing and Sales	African Astronautics	tlewis@afronautics.com
Koos Eloff	Acting Research and Technology Manager/Centre Manger	Agricultural Research Council, Institute for Soil, Climate and Water	
Adri Theron	Public Relations Officer	Agricultural Research Council, Institute for Soil, Climate and Water	adril@arc.agric.za
Terry Newby	Manager, Natural Resources Databases and Manager Geo- informatics	Agricultural Research Council, Institute for Soil, Climate and Water	
Harold Weepener	Geo-informatics, Manager Geographical Information Systems	Agricultural Research Council, Institute for Soil, Climate and Water	
Sylvester Mpandeli	Program Manager, Agrometeorology	Agricultural Research Council, Institute for Soil, Climate and Water	

Chris Kaempffer	Agrometeorology, Climate Network Manager	Agricultural Research Council, Institute for Soil, Climate and Water	
Adam Loock	Division Manager, Analytical Services, Soil and Water Analysis	Agricultural Research Council, Institute for Soil, Climate and Water	
Nina van Vliet	Analytical Services, Plant and Ameliorant Analysis	Agricultural Research Council, Institute for Soil, Climate and Water	
Dave Turner	Manager, Pedology and Soil Mineralogy	Agricultural Research Council, Institute for Soil, Climate and Water	
Johan Carstens	Manager, Natural Resources and Production Economics	Agricultural Research Council, Institute for Soil, Climate and Water	
Danie Beukes	Manager Soil and Water Science	Agricultural Research Council, Institute for Soil, Climate and Water	
Hilmy Sally	Head, Southern Africa	International Water Management Institute	h.sally@cgiar.org
Akica Bahri	Director, Africa,	International Water Management Institute	a.bahri@cgiar.org
Pius Chilonda	Sub-Regional Coordinator	International Water Management Institute	p.chilonda@cgiar.org
Christian Cheron		International Water Management Institute, Rural Engineering Water and Forestry	c.cheron@cgiar.org
Mutsa Masiyandima	Hydrologist	International Water Management Institute	m.masiyandima@cgiar.org
Craig Schwabe	Director, GIS Center	Human Sciences Research Council	CASchwabe@hsr.ac.za
Gina Weir-Smith	Chief GIS Specialist	Human Sciences Research Council	gweir-smith@hsr.ac.za
Betsy Scally	Chief, Pretoria Bureau	Open Source Center	scallyem@state.gov
Raoul C. Hodges	Operations Manager and Center Chief	Council on Scientific and Industrial Research (CSIR), Satellite Applications Centre	rhodges@csir.co.za
Corne Eloff	Earth Observation Service Centre Manger	CSIR-Satellite Applications Centre	celoff@csir.co.za
Bruno Meyer	Remote Sensing Project Manager	CSIR-Satellite Applications Centre	bmeyer@csir.co.za
Buks Venter	Management Consultant	SunSpace Innovative Satellite Solutions	buks@sunspace.co.za
Mark Becker	Associate Director, Geospatial Applications Division	Center for International Earth Science Information Network (CIESIN), Columbia University	mbecker@ciesin.columbia.edu

Appendix 5: Abbreviations

Abbreviations

AAG	American Association of Geographers
AARSE	African Association for Remote Sensing of the Environment
ACMAD	African Centre of Meteorological Application for Development
ADIE	Agence de l'Informatique De l'Etat
AGIRN	African Geo-Information Research Network
AGIS	Abuja Geographic Information Systems
AGRHYMET	Centre Régional de Formation et d'Application en Agrométéorologie, Hydrologie et Météorologie
AGS	American Geographical Society
ARC-ISCW	Agricultural Research Council – Institute for Soil, Climate, and Water
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVHRR	Advanced Very High Resolution Radiometer
BIDPA	Botswana Institute for Development Policy Analysis
CBNRM	Community-Based Natural Resource Management
CEOS	Committee on Earth Observation Satellites
CG	Used interchangeably with CGIAR
CGIAR	Consultative Group on International Agricultural Research
CGIS-NUR	Centre of Geographic Information Systems and Remote Sensing– National University of Rwanda
CODI	U.N. E.C.A. Committee on Development Information (now renamed, below)
CODIST	U.N.E.C.A. Committee on Development Information, Science and Technology
CRESA	Centre Régional d'Enseignement Spécialisé en Agriculture
CSE	Centre de Suivi Ecologique
CSIR	Council for Scientific and Industrial Research
DFID	Department for International Development (UK)
DGS	Department of Geological Survey (Botswana)
DST	Department of Science and Technology (South Africa)
DTGC	Direction des Travaux Géographiques et Cartographiques
ECOWAS	Economic Community of West African States
EDC	EROS Data Center
EIS	Environmental Information Systems
EIS-AFRICA	Environmental Information Systems-Africa
ERDAS	Earth Resource Data Analysis System
EROS	Earth Resources Observation Systems (USGS)
ESA	European Space Agency
ESRI	Environmental Systems Research Institute
FAO	Food and Agriculture Organization (UN)
FEWS NET	Famine Early Warning System Network
FUT	Federal University of Technology
GBM	Green Belt Movement
GDEST	Global Dialogues on Emerging Science and Technology
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GIS	Geographic Information System
GISD	Geographic Information for Sustainable Development
GRS	Geodetic Reference System
GST	Geospatial Science and Technology
HOORC	Harry Oppenheimer Okavango Research Centre
ICPAC	IGAD Climate Prediction and Application Centre

ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IGAD	Intergovernmental Authority on Development
IGARSS	International Geoscience and Remote Sensing Symposium
IGB	Institut Géographique du Burkina Faso
IGN	Institut Géographique National (Niger)
IGOS	Integrated Global Observing Strategy
IRD	Institut de Recherche pour le Développement
ISDR	International Strategy for Disaster Reduction
IT	Information Technology
IUCN	International Union for Conservation of Nature
LERG	Laboratoire d'Enseignement et de Recherche en Géomatique
LTA	Laboratoire de Télédétection Appliquée
MINITERE	Ministry of Lands, Environment, Forestry, Water, and Mines
MODIS	Moderate Resolution Imaging Spectroradiometer
MUIENR	Makerere University Institute of Environment and Natural Resources
NACA	National AIDS Coordinating Authority (Botswana)
NASA	National Aeronautics and Space Administration
NASRDA	National Space Research and Development Agency
NBI	Nile Basin Initiative
NDVI	Normalized Difference Vegetation Index
NEMA	National Emergency Management Agency (Nigeria) National Environment Management Authority (Uganda)
NEPAD	New Partnership for Africa's Development
NGA	National Geospatial-Intelligence Agency
NGO	Non-Governmental Organization
NGSA	Nigeria Geological Survey Agency
NOAA	National Oceanic and Atmospheric Administration
NUR	National University of Rwanda
OACT	Organisation Africaine de Cartographie et de Télédétection
OCHA	Office for the Coordination of Humanitarian Affairs (UN)
OES	Bureau of Oceans, Environment, and Science (U.S. Department of State)
OPM	Office of the Prime Minister
PRIME/WEST	Productive Resource Investments for Managing the Environment– Western Region
RCMRD	Regional Center for Mapping of Resources for Development
RECTAS	Regional Centre for Training In Aerospace Surveys
RITA	Rwanda Information Technology Authority
RRSU	Regional Remote Sensing Unit
RS	Remote Sensing
S&T	Science and Technology
SAC	Satellite Applications Centre (CSIR)
SADC	South African Development Community
SAEON	South African Environmental Observation Network
SAFNET	Southern Africa Fire Network
SAWS	South African Weather Service
SDI	Spatial Data Infrastructure
SETES	SADC EIS Training and Education Sub-program
SIDA	Swedish International Development Cooperation Agency
SIGET	Système d'Information Géographique et Télédétection
SPOT	Satellite Pour l'Observation de la Terre
SRTM	Shuttle Radar Topography Mission
UBOS	Uganda Bureau of Statistics
UCAD	Université Cheikh Anta Diop du Sénégal
UN	United Nations

UNECA	United Nations Economic Commission for Africa
UNEDRA	University Network for Disaster Risk Reduction in Africa
UNFPA	United Nations Population Fund
UN-SPIDER	United Nations Platform for Space-based Information for Disaster Management and Emergency Response
USAID	United States Agency for International Development
USGS	United States Geological Survey
WGS	World Geodetic System
WMO	World Meteorological Organization
WSSD	World Summit on Sustainable Development